

# TSUNAMI NEWSLETTER

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# TSUNAMI NEWSLETTER - JULY 1994

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The TSUNAMI NEWSLETTER is published semi-annually by the International Tsunami Information Center (ITIC) to bring news and information to scientists, engineers, educators, community protection agencies, and governments throughout the world.

We welcome contributions from our readers.

The ITIC is maintained by the U.S. National Oceanic & Atmospheric Administration (NOAA) for the Intergovernmental Oceanographic Commission (IOC). The Center's mission is to mitigate the effects of tsunamis throughout the Pacific.



## MEMBER STATES

*Present membership of the IOC International Coordination Group for the Tsunami Warning System in the Pacific (ICG/ITSU) comprises the following 26 States:*

AUSTRALIA

CANADA

CHILE

CHINA

COLOMBIA

COMMONWEALTH OF INDEPENDENT  
STATES, RUSSIAN FEDERATION

COOK ISLANDS

COSTA RICA

DEMOCRATIC PEOPLE'S REPUBLIC  
OF KOREA

ECUADOR

FIJI

FRANCE

GUATEMALA

INDONESIA

JAPAN

MEXICO

NEW ZEALAND

NICARAGUA

PERU

PHILIPPINES

REPUBLIC OF KOREA

SINGAPORE

THAILAND

UNITED KINGDOM (HONG KONG)

UNITED STATES OF AMERICA

WESTERN SAMOA

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## In Memory of Professor Sergei Soloviev (1930-1994)

*The news of Prof. Sergei Soloviev's sudden death on March 9, 1994, saddened the international tsunami community where he established himself as a renowned tsunami researcher and leader in fostering the development of international scientific cooperation. Fellow tsunami researchers, scientists and his many friends will remember his spirit of cooperation in furthering the science of tsunamis and the mitigation of their effects. We will miss his diligence, professionalism and friendly personal manner.*

Prof. Sergei Soloviev was born on April 12, 1930, in the ancient Russian city of Novgorod. He attended secondary school in Novgorod, but in 1941 had to evacuate to Kostroma due to the German invasion. In 1947 he finished secondary school in Leningrad with the gold medal award and began the study of physics at Leningrad University where he specialized in geophysics. He became especially interested in the problems of observational seismology. Sergei graduated from the University in 1953 and continued his education with post-graduate courses at the Geophysical Institute (now the Institute of Physics of the Earth) in Moscow. He was a student of Prof. E. Savarensky, a leading Russian seismologist, who was Director of the Moscow Seismological Observatory. As the main subject for his research work, Prof. Savarensky proposed a serious (for the graduate student) task to adjust the magnitude scale introduced by K. Richter and B. Gutenberg in the USA, for the regional earthquakes recorded in the USSR.

In 1956, Sergei finished the graduate courses and defended his Master's thesis entitled "Magnitude Classification of the Earthquakes in the USSR." In the same year he became a junior researcher in the Institute. As a part time job he took a position of the Learned Secretary of the Seismological Council of the USSR Academy of Sciences and continued until 1961. His main work during this period of almost five years was editing the fundamental book prepared by the group of authors entitled "Atlas of the Earthquakes in the USSR." This book was the first attempt to collect the original observational data on all historical earthquakes in Soviet territory and classify them on the basis of the unified magnitude scale.

In 1961, he moved from Moscow to Sakhalin and took the position of Head of the Seismological Department of the

Sakhalin Complex Research Institute (SCRI). Due to the geographical position of the institute near one of the most active segments of the Pacific "Ring of Fire," the tsunami problem inevitably became the focus of his attention. He helped established the Soviet Tsunami Warning System on the Far East coast, and proposed and elaborated a set of magnitude criteria for issuing the tsunami warnings. He established the Hydrophysical Observatory on Shikotan Island where the experimental work on T-phase observations and the direct bottom measurements of tsunami by cable sensors started in 1963.

Among the scope of his research work at that time was the investigation of seismicity of the Sakhalin area which resulted in the publication of the first monograph on this subject. The compilation of observational data for the tsunami occurrence in the Pacific region was made during this period. Two volumes of the tsunami catalogs for the Pacific were published in Moscow in 1974-75 and later were translated into English. For a whole generation of tsunami researchers in the Soviet Union these books were the primary source of information for historical tsunami data.

In 1965, Sergei Soloviev was appointed Deputy Director of the SCRI; however, in 1968 due to the illness of his daughter, he had to return to Moscow and during the next three years he again worked in the Institute of Physics of the Earth. There he prepared and in 1970 defended his Ph.D. thesis entitled

"Seismological Aspects of Tsunami Occurrence." In 1972, he was elected as a Corresponding Member of the Academy of Sciences of the USSR. Soon after that he was invited back to Sakhalin and took the vacant position of Director of the SCRI. During the next several years he reactivated the institute and initiated several new projects. One of his primary concerns was the development of the research and technical basis of the Institute. As a result, the Institute obtained three research vessels; *Pegas*, *Sea Geophysics*, and *Audacious*, and the intensive program of geophysical investigation of the Okhotsk and adjacent seas was started.

In these years, the first steps in the Soviet-American cooperation in the field of tsunami research were taken. Prof. Soloviev was at the forefront of these programs and actively supported all cooperative projects. He took part in the Washington (1974) and Novosibirsk (1976) USA-USSR meetings of experts on the tsunami problem and initiated two joint Soviet-American tsunami expeditions in the Kuril-Kamchatka region. His good command of the English language was revealed during these activities.



In 1971, he was elected as Chairman of the IUGG Tsunami Commission and held this position until 1979. In 1985, he attended the Tsunami Symposium in Victoria (Canada) where he was awarded the special IUGG Memorial Plate for his active research in the field of tsunami problems. In 1988, he received the Adams Award in recognition of his long-term contributions in tsunami research. At ITSU-XI, in Beijing 1987, Prof. Soloviev was elected Vice-Chairman of the Group.

In 1977, Prof. Soloviev returned to Moscow from Sakhalin and took the position of Chairman of Seismological Council of the USSR Academy of Sciences. His work during this period was connected with automation of seismological observations in the USSR territory for the Academy of Science, and included initiation of the program for detailed estimation of seismic risk in earthquake-prone zones of the USSR. Following his retirement from the position in 1978, he moved to the Institute of Oceanology where he led the Institute's program of ocean bottom seismology. He had gained experience in this field when in Sakhalin, where the first work on the development and construction of Ocean Bottom Seismographs (OBS) started in the 1970's. Several new types of the OBSs were developed and manufactured at the Institute's design bureau in Gelengic on the Black Sea. Prof. Soloviev participated in several cruises of the

research vessel *Dmitriy Mendeleev* in the Mediterranean and the Atlantic where the new OBSs were successfully deployed. Results of his work for this period were summarized in the book "History and the Perspectives of Sea Seismology," published in Moscow in 1985. Despite the fact that ocean bottom seismology became the primary part of his official work in the Academy of Sciences, Prof. Soloviev continued his active participation in coordination of tsunami research and investigation in the Soviet Union and encouraged greater international cooperation. Since 1971, he was the permanent Chairman of the Tsunami Commission of the USSR Academy of Sciences and his leadership in this field was recognized by all his colleagues. He always paid special attention to the involvement of young scientists and worked to attract the attention of specialists from other fields to the tsunami problem.

Prof. Soloviev died on March 9, 1994, at the age 63, from cerebral thrombosis while he was working in his Moscow apartment, editing his second book on ocean bottom observations. He recently completed a Catalogue of Tsunamis in the Mediterranean Sea, which is ready for publication.

*The editor thanks Slava Gusiakov and George Curtis for collaborating on this remembrance of Prof. Soloviev*



## NEWS EVENTS

### **Earthquake and Tsunami Report, December 1993 through June 1994 Three Local Tsunamis Generated**

*The last seven months have seen a very high level of seismic activity worldwide, particularly in the Pacific Basin. During the month of June alone the following activity was reported:*

A destructive earthquake and tsunami occurred in Indonesia on June 3 (local time) causing extensive damage and numerous casualties along the Indian Ocean coastline of Java Island. Tsunami runup was measured at 11+ meters in some areas (see related articles for additional information). Earlier this year on January 21, Indonesia was hit by an earthquake and tsunami in the Halmahera Island region. Two large earthquakes in South America (Colombia and Bolivia) occurred in early June, too. The June 6, 1994, Colombia event killed 271 people when mud, rock and ice flows crashed into several small villages on the slopes of Huila volcano.

According to the United States Geological Survey, the Colombia temblor had a surface wave magnitude of 6.7 and occurred about 200 kilometers southwest of Bogota. Some damage and power outages were reported in Bogota. The June 9, 1994, Bolivia earthquake, the most powerful so far this year with a body wave magnitude of 8.2, occurred at a depth of 600 kilometers and was felt as far away as Canada! The Bolivia and Colombia earthquakes did not generate tsunamis.

A strong earthquake of magnitude 6.5, at a depth of 16 kilometers, occurred off the east coast of Taiwan at 09:10 June 5, local time. The temblor was felt acutely on Taiwan, and power outages were reported. A news report from Japan indicated the earthquake was felt on Ishigaki, Irimote and Yonaguni Islands in Okinawa Prefecture. The Japan Meteorological Agency issued a tsunami warning for the coasts of the Okinawan Islands but lifted it one hour later when (apparently) no tsunami wave activity was reported. The earthquake was also felt in mainland cities along the Taiwan Straits.

**And, a brief synopsis of other significant earthquakes:** A devastating earthquake with a surface wave magnitude of 6.6 (subsequently revised to 6.8) severely jolted the Northridge area of the Los Angeles Basin during the early morning hours of January 17, 1994. Due to the earthquake's location (inland) no tsunami was generated, however, many casualties and significant property damage were reported (see related article). The extensive destruction caused by this earthquake has created an increased awareness among disaster preparedness authorities and researchers looking at multihazard mitigation in southern California. The potential for local tsunami generation in this area is very probable based upon consideration of a number of active offshore faults and submarine slopes covered with unconsolidated sediments. To mitigate this local tsunami hazard, it has been suggested that an evaluation of tsunami

source areas in southern California be undertaken and that a tsunami generation model be developed in conjunction with inundation maps for coastal communities that are at the greatest risk.

A large surface wave magnitude 7.2 earthquake hit the Halmahera Island region of Indonesia on January 21, 1994, and caused a tsunami with a maximum runup of two meters (see related article). Two days earlier, a magnitude 6.9 earthquake struck the West Irian Jaya region of the island of New Guinea. On 15 February, a magnitude 7.0 earthquake hit the southeastern end of Sumatra Island, Indonesia. There has been an extremely high level of large, destructive earthquake activity in Indonesia since the beginning of this year.

A sharp temblor shook Japan's Hokkaido and north Honshu islands on April 8. A U.S. newspaper reported a small tsunami was generated and "washed harmlessly ashore." Investigation by the Japan Meteorological Agency (JMA) reported the magnitude 6.6 earthquake produced a small (<10 cm) amplitude tsunami that was recorded by tide gauges at Hachinohe and Ayukawa in Japan. A tsunami with 22 cm amplitude was recorded at the Ofunato tide gauge by the JMA.

### **Powerful Earthquake and Killer Tsunami Hits Indonesia on June 3, 1994**

A major earthquake and resulting destructive tsunami with waves reported in excess of 11 meters caused numerous casualties and damage along the Indian Ocean coastline of Java (island) Indonesia. The earthquake, reported with a surface wave magnitude of 7.2 and moment magnitude of 7.7, occurred in the Java Trench about 225 km south-southeast of Malang on June 2 at 18:18 UTC (June 3 at 01:18 local time in Java). The U.S. Geological Survey, National Earthquake Information Center, also reported a strong aftershock with a surface wave magnitude 6.4 occurred on June 4 at 04:07 local time in the same area. Researchers are drawing similarities between this earthquake/tsunami and the one that occurred in Nicaragua in 1992. Analysis of the seismic data indicates that the focal mechanism for this event is of the thrust type with a shallow dip angle.

Initial accounts from Indonesia's Meteorological and Geophysical Agency (MGA) reported that a tsunami hit coastal areas in Banyuwangi district and killed 204 people; some 22 people were reported as missing. The report also said that 1226 homes in the disaster area were destroyed. In a report dated June 17, the DHA-Geneva indicated 222 people were killed, 17 missing and 440 wounded by the tsunami. Total monetary losses were estimated at US\$2.2 million. Survivors of the tsunami said the waves hit unexpectedly but recounted they heard a roaring sound as the tsunami smashed ashore. At first they thought it was the sound of the wind until they were suddenly hit by the water (The Jakarta Post). According to Mr. Soetardjo, an MGA survey team reported the tsunami swept inland about 300 meters in some areas. Numerous small boats

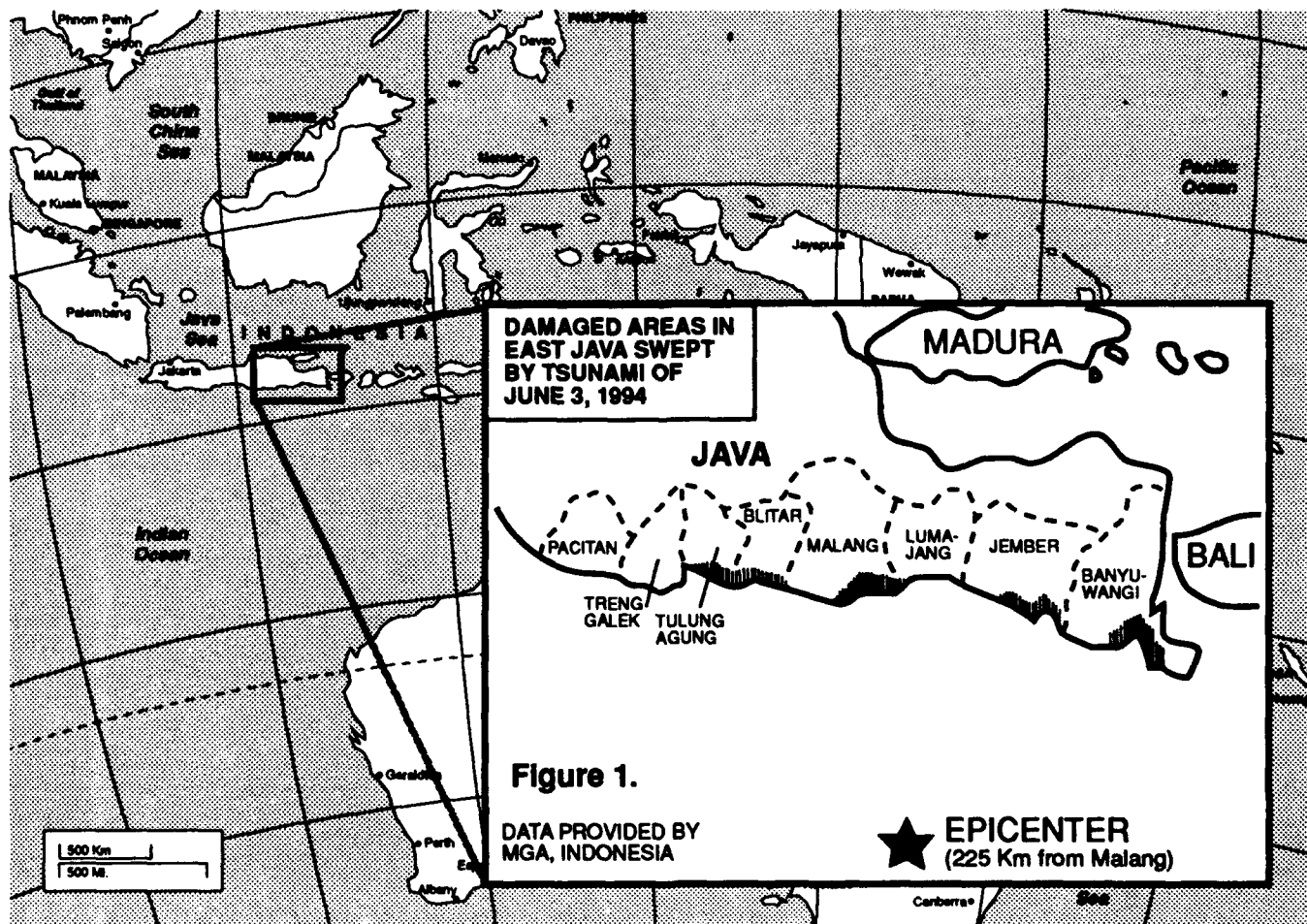
## NEWS EVENTS

were sunk or destroyed. (see figure 1. for tsunami damaged areas in eastern Java) Indonesia's President Suharto visited the affected areas on June 14. Numerous aftershocks continue to occur in the area.

At press time, survey teams from Japan, Italy, Thailand and the United States were joining teams from Indonesia to collect additional field data on this locally destructive tsunami (see related article, *Preliminary Report, 1994 East Java Indonesia Earthquake and Tsunami*, in this Newsletter). Prof. N. Shuto, at Japan's Tohoku University, completed numerical simulations of the tsunami but the runups fell short of the high runups reported in the Banyuwangi district. Field data covering a wide area and additional runup measurements will help numerical modelers better understand this type of earthquake and resulting (high) runup values. Additional seismic aftershock data will help to better define the overall size of the earthquake source area. Tide gauge data from Broome, Cocos Island and Darwin (Australia) were evaluated for tsunami wave action, however, it is not clear if a tsunami was recorded due to background noise and the small amplitude of (any) tsunami wave activity. A more complete report on this tsunami will appear in the December 1994 ITIC Newsletter.

## Earthquake Jolts Los Angeles Basin, US\$15+ Billion in Damage Reported

The severe ( $M_s=6.8$ ) earthquake that jolted the San Fernando Valley, 35 miles northwest of Los Angeles, California, on January 17th caused extensive property damage and numerous casualties but did not generate a tsunami. The earthquake actually raised parts of the Northridge area by nearly a meter with an equal amount of slumping reported in the San Fernando Valley. Elevated freeways, parking garages, apartments and other structures collapsed under the severe ground motions caused by this shallow (10 km.) earthquake. Unlike earthquakes associated with the well known San Andreas fault, this earthquake occurred in an area of *thrust* faulting that produced a strong, jarring upward motion that last for nearly 35 seconds. Numerous aftershocks, extending over a two week period, rattled the immediate area. This has been one of the most costly natural disasters to hit the United States, on par with damage inflicted by recent events such as the 1989 San Francisco earthquake and 1992's Hurricane Andrew in southern Florida. It was reported by some pet owners, particularly those with birds, that their animals had given advance warning of the earthquake by acting strangely seconds before the violent





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ground motion began. By April, collapsed sections of the Santa Monica freeway had been replaced and opened to traffic.

A *Tsunami Information Message* issued by the Alaska Tsunami Warning Center (ATWC) in Palmer, Alaska, indicated a preliminary surface magnitude of 6.7 at 12:31 UTC, January 17, 1994 for the Northridge event. ATWC has the regional tsunami warning responsibility for the area.

### Halmahera Island (Indonesia) Earthquake and Tsunami, January 21, 1994

A strong magnitude Ms 7.2 earthquake struck the Halmahera Island region of Indonesia at 02:24Z January 21, 1994. PTWC located the event at 1.3N and 128.0E. A report issued by the wire services said "the quake damaged roads and an airport in the Halmahera Islands and generated a tsunami that washed about one-half mile inland." Subsequent reports issued by the UN - Department of Humanitarian Affairs (Geneva) said seven people were killed and 40 injured near the northern isthmus of Halmahera Island (later reports indicated nine people died and 300 injured). Severe damage to housing, government buildings, and public facilities were reported. Minor tidal waves (tsunami) of 2 meters were reported from the western coast of Halmahera Island. Mr. Sunarjo, the ITSU National Contact in Indonesia, was contacted by ITIC and provided the following information:

After the Halmahera earthquake of January 21, the Indonesia Meteorological and Geophysical Agency sent a team to the site to investigate the effects of the earthquake and tsunami. The survey was conducted from January 25 to February 2.

They reported that this earthquake was followed by a small tsunami with a height (runup) of less than one meter at the villages of Kao and Malifut (Halmahera Island). According to a local account, the tsunami height reached 2 meters (runup) to the north at the village of Payout (the MGA team did not confirm this report due to transportation difficulties in reaching the village). They said the earthquake caused much damage and killed two people, but NO tsunami casualties or damage were reported.

### Sumatra Island (Indonesia) Earthquake of February 15, 1994

A devastating (M<sub>s</sub>) magnitude 7.0 earthquake struck Lampung Province, Indonesia, during the early morning hours of February 16, 1994 (17:08 UTC, 15 February). Heavy property damage and a casualty count of at least 207 with many others injured made this the second severe earthquake to strike Indonesia since the beginning of the new year. Based on a report from Dr. Paulus Winarso of the Indonesian Meteorological and Geophysical Agency in Djakarta, no tsunami was generated. The earthquake triggered landslides and disrupted transportation services

and communications in rural areas. (information reference: DHA-Geneva)

### Hokkaido Nansei-Oki (Sea of Japan) Earthquake and Tsunami of July 12, 1993

In addition to reports covered in the December 1993 ITIC Newsletter, the following accounts on the Hokkaido Nansei-Oki earthquake/tsunami have been received at ITIC.

### Tsunami Runup Distribution in Russia, Dr. Peter N. Nikitin

Dr. Peter Nikitin, Head - Arctic, Antarctic and Marine Department, Hydromet, Moscow, provided a detailed description of tsunami events in Russia following the July 12, 1993, Hokkaido Nansei-Oki Earthquake. According to his report, shortly after midnight (local time) the residents of the Prymorie region felt a moderate earthquake. It caused the shaking of furniture and chandeliers and also an odd behavior in animals, birds and fish. About 50 to 70 minutes later, the first tsunami waves arrived. Three main waves were registered, but at some points (Rudnaya Pristan, Kamenka) up to 18 minor waves were reported. In enclosed bays, sea level oscillations (seiche) were observed until noon (local time) on July 13.

At almost all coastal points that reported tsunami activity, it was recounted the wave arrival appeared smoothly, in the form of a very high tide. But, during a short time (a few minutes) prior to the initial wave arrival, a booming sound was heard at sea ... similar to the sound of a tractor engine. The maximum tsunami wave height was registered at p. Valentina and Rudnaya Pristan Bay (up to 4 m). Damage resulting from the tsunami waves is estimated at US\$10 million. There was no account of injuries or fatalities in Dr. Nikitin's report.

### Maximum Tsunami Wave Heights and Run-ups in Meters at Locations in Russia, 12 July 1993

Location	Run-up	Flooding	Time (GMT, 12 July 1993)
	vertical (m)	horizontal (m)	
Kamenka	2.79	15	-
Rudnaya Pristan	3.78	140	14:15 - 15:03
Zerkalnaya	2.34	146	
Valentina	4.00	85	
Preobrazhenia	1.25		14:20
Nakhodka	0.98		14:30 - 17:20
Olga	~1.5		15:15
Belkin	0.60		21:03

Notes: The reading on the tide gauge at Nevelsk showed on July 12, 1993, between 15:00 and 23:30 GMT, sea level oscillations in the range of (maximum) 55 cm and (minimum) 48 cm

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### Post-Tsunami Survey Photographs, Okushiri Island

ITIC has assembled an assortment of digitized color photographs depicting tsunami runup and associated damage on Okushiri Island resulting from the July 1993 Sea of Japan tsunami. Originally photographed on Ektachrome slide film, the high quality digital imagery was provided to NOAA's National Geophysical Data Center (NGDC) in Boulder, Colorado. NGDC is planning to distribute the photographs (as color slides and eventually digitized on CD-ROM) through their subscription service. (*see related article*).



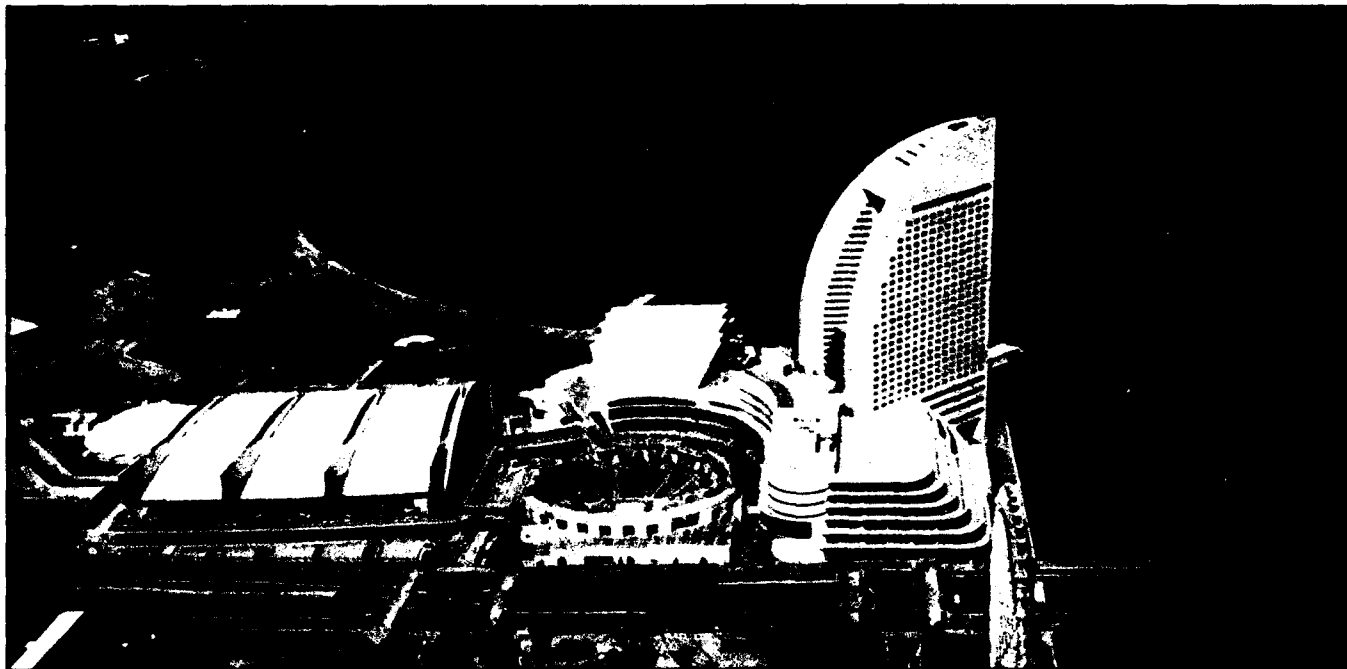
*Shigenobu Tanaka (l.), Public Works Research Institute, describes hydraulic model of southern Okushiri Island to Eiichi Honza (r.), Geological Survey of Japan.*

### Seismic and Geologic Data From the Japan Sea

The Geological Survey of Japan (GSJ) is conducting a thorough investigation into the source mechanism of the Hokkaido Nansei-Oki earthquake. During a recent visit to the GSJ's national headquarters in Tsukuba, Japan, the Acting Director, ITIC, reviewed field data (ocean bottom profiles) provided by Dr. Yukinobu Okamura that show a series of thrust faults in the source area. It is hoped that further analysis of the field data will give greater insight into the amount and extent of deformation associated with the faulting. Dr. Eiichi Honza of the GSJ arranged Dennis Sigrist's visit to Tsukuba while Dr. Augustine Furumoto, Hawaii State Tsunami Advisor, participated in the meetings. Dennis Sigrist also met with Dr. Masami Okada and was introduced to Dr. Akira Harada, Director-General of Japan's Meteorological Research Institute. Dr. Sinito Iwasaki, Senior Researcher at Japan's National Research Institute for Earth Science and Disaster Prevention, led an interesting discussion on tsunami forecasting.

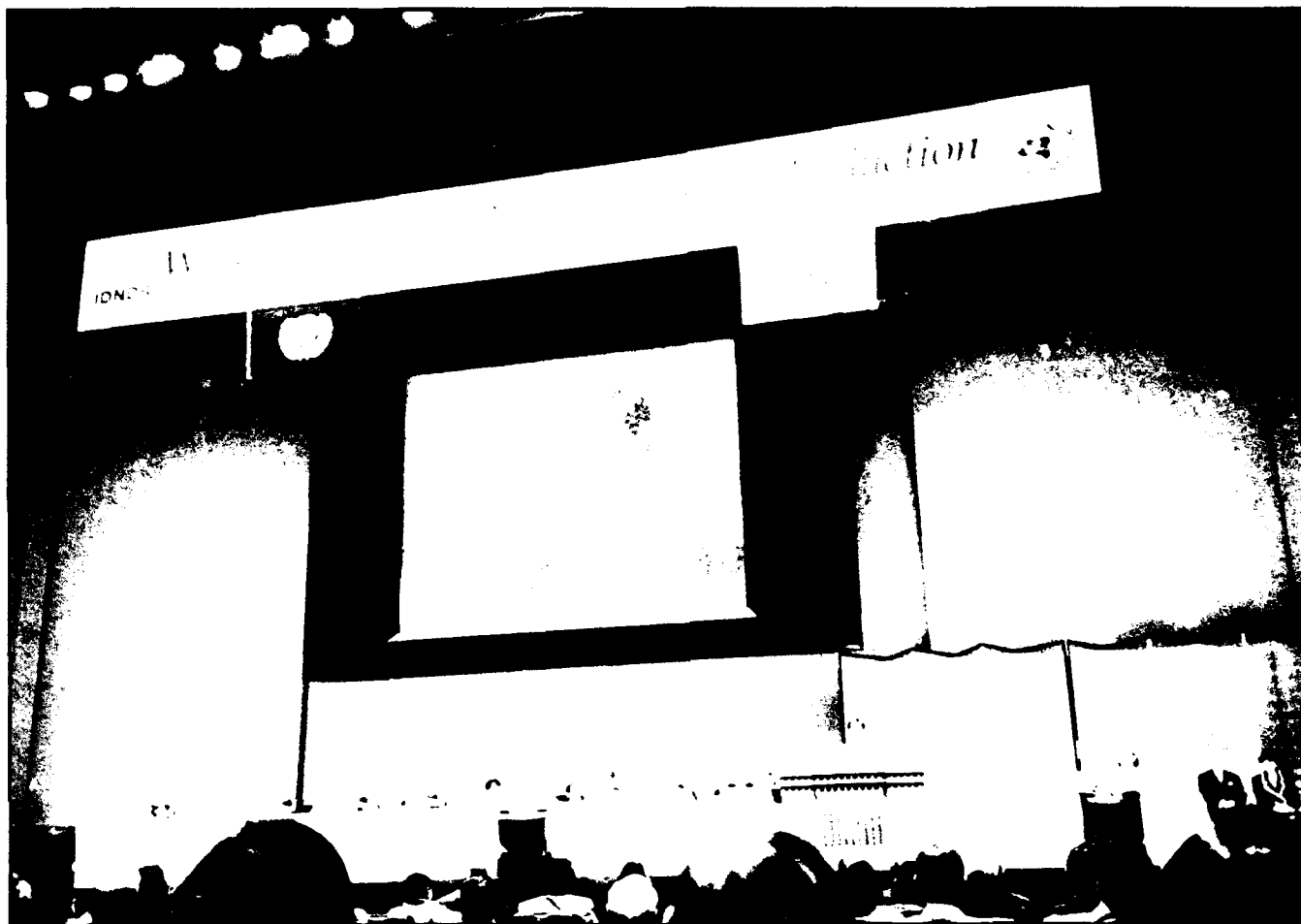
### Hydraulic Model of Southern Okushiri Island

Japan's Ministry of Construction, Public Works Research Institute, has carried out a hydraulic model experiment of southern Okushiri Island to investigate tsunami wave runup and interaction along the coastal areas near to and including the community of Aonae. Shigenobu Tanaka, Head of the Coastal Engineering Division, led a group of researchers, including ITIC's Acting Director, through their hydraulic modeling facility in Tsukuba, Japan (*see photograph*). Results of the



*View of the Pacifico Conference Center from the Landmark Tower Building; Yokohama Bay is in the background*

## IOC - ICG/ITSU



*Japan's Crown Prince Naruhito addresses the opening session of the World Conference on Natural Disaster Reduction in Yokohama.*

experiment are summarized in a related article, *Propagation of Hokkaido Nansei-Oki Tsunami*, later in this Newsletter.

## IOC - ICG/ITSU

List of National Contacts, Correction

The following correction to the list of ICG/ITSU National Contacts published in the December 1993 ITIC Newsletter reflects changes received at ITIC through 1 July 1994. As always, please inform ITIC whenever there are changes.

### **Ecuador**

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## INTERNATIONAL DECADE FOR NATURAL DISASTER REDUCTION (IDNDR)

### **IDNDR Report, Yokohama World Conference - May 1994**

The World Conference on Natural Disaster Reduction, hosted by the Government of Japan in Yokohama during the period of May 23 - 27, brought together a diverse group of international participants that evaluated progress in achieving the goals of the IDNDR. This mid-term review, through plenary and technical sessions, focused on a variety of research topics, national and local experiences, and policy matters in achieving the Decade's targets of assessing a nation's risk to natural hazards, establishing preparedness and mitigation plans, and the need for access to warning systems. During the week-long course of the meeting, poster sessions and exhibits provided an in-depth look at a broad range of research projects, technology and policy implementation, and initiatives related to natural disaster reduction. The Conference was attended by over 2,000 individuals

## IDNDR

representing 148 countries, non-governmental organizations, international organizations, the scientific community, business, industry, and the media. The Government of Japan, and in particular the City of Yokohama, provided an outstanding conference facility, generous hospitality, and the opportunity to gather such a diverse group of international participants concerned with the mitigation of natural disasters.

The Conference officially opened on Monday, May 23, 1994, and received very high recognition with the attendance of Japan's Crown Prince Naruhito and Crown Princess Masako. The Conference heard a video presentation by the Secretary-General of the United Nations followed by Crown Prince Naruhito who spoke at the opening plenary session. The Conference elected, by acclamation, as the President of the Conference, Mr. Nobutoshi Akao, Ambassador for Global Environmental Affairs and International Trade of Japan. Prof. G.O.P. Obasi (Secretary-General of the World Meteorological Organization) and Dr. Frank Press (father of the IDNDR) officially opened the poster session during a ribbon cutting ceremony on May 24. ICG/ITSU was well represented at the Conference. Mr. Emilio Lorca, Chile, addressed Technical

Committee F discussing the Pacific Tsunami Warning System on Thursday, May 26. Salvador Farreras, Mexico, participated in the poster display session with an excellent presentation on "Tsunami Vulnerability Reduction Activities in Mexico." Hiroo Uchiike, Japan's ITSU National Contact, had a very informative poster on the Japan Tsunami Warning System.

UNESCO and IOC conducted a week-long exhibit depicting a number of activities, including posters on tsunami research and warning systems, in the 6th floor exhibition hall of the Conference Center. Dr. Youri Oliounine, Senior Assistant Secretary, attended as senior representative of the IOC. ITIC, represented by Acting Director Dennis Sigrist, displayed posters on the 1993 Sea of Japan Tsunami, New Technology Tsunami Detection and Warning Systems, Tsunami Educational Materials and tsunami modeling videos. Without the tremendous on-site support of individuals representing UNESCO, IOC, ITIC, local agencies and staff, the Japan Meteorological Agency, Tohoku University, and so many others, the exhibit would not have been successful. Most of the hand-out materials that were prepared for the exhibit were eagerly taken by the many visitors that attended the Conference.



*At the IOC display, 6th floor Conference Center. Left to right; Tomoyuki Takahashi (Japan), Salvador Farreras (Mexico), Emilio Lorca (Chile), Youri Oliounine (IOC), and Dennis Sigrist (ITIC)*

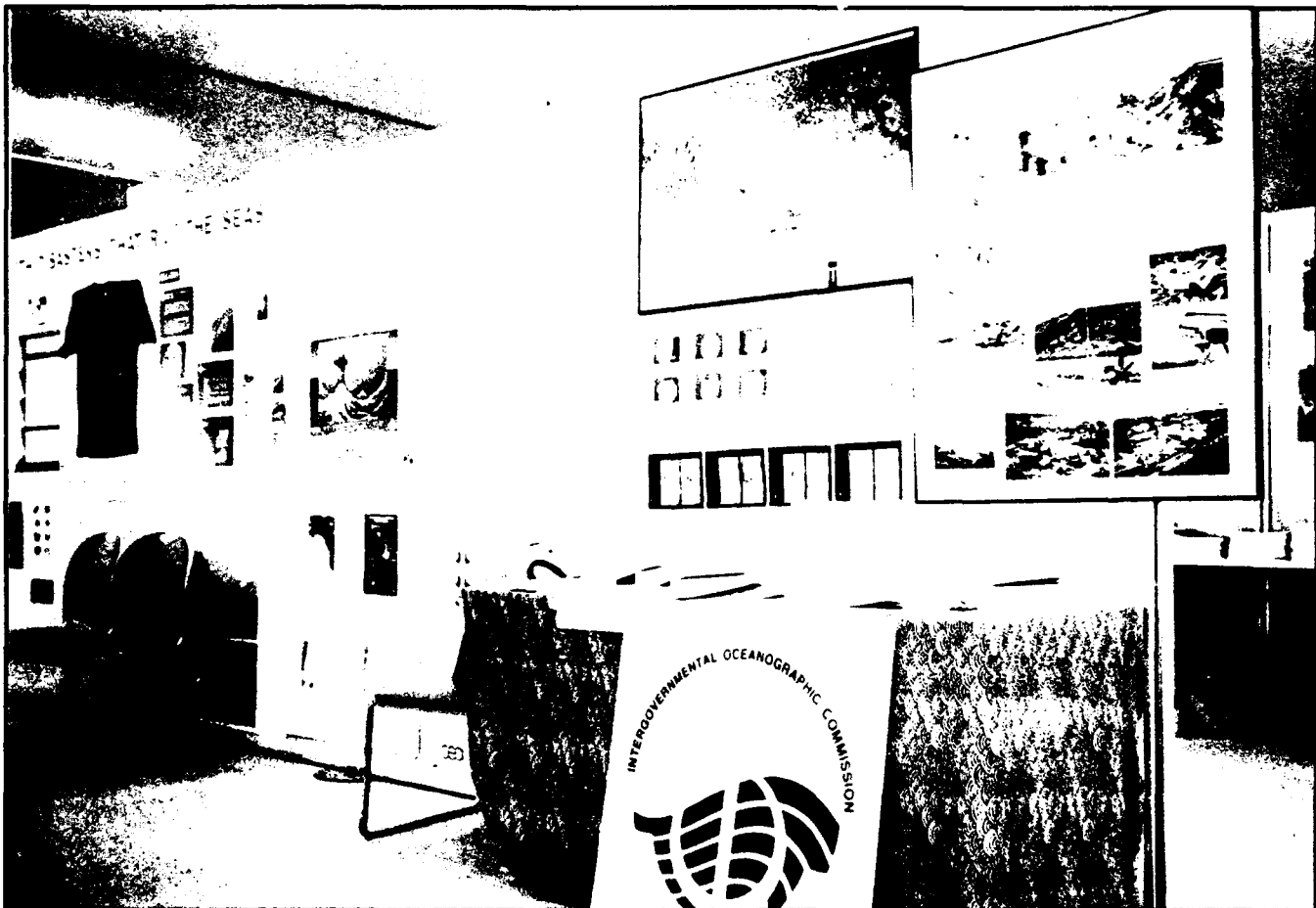
## IDNDR

### *The Conference adopted the following principles:*

1. Risk assessment is a required step for the adoption of adequate and successful disaster reduction policies and measures.
2. Disaster prevention and preparedness are of primary importance in reducing the need for disaster relief.
3. Disaster prevention and preparedness should be considered integral aspects of development policy and planning at national, regional, bilateral, multilateral and international levels.
4. The development and strengthening of capacities to prevent, reduce and mitigate disasters are a top priority area to be addressed during the Decade so as to provide a strong basis for follow-up activities to the Decade.
5. Early warnings of impending disasters and their effective dissemination using telecommunications, including broadcast services, are key factors to successful disaster prevention and preparedness.
6. Prevention measures are most effective when they involve participation at all levels, from the local community through the national government to the regional and international level.

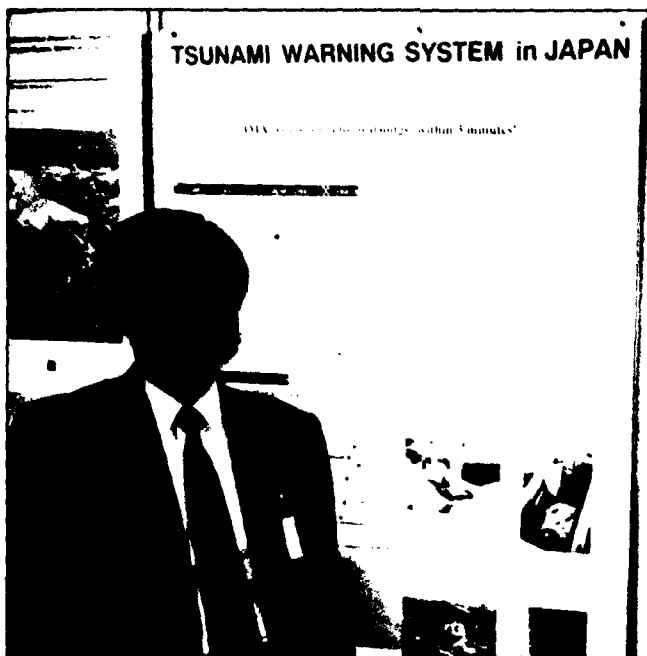


*Prof. G.O.P. Obasi (l.), World Meteorological Organization, and Dr. Frank Press (r.), father of the IDNDR, officially open the poster session*



*IOC display, Tsunami-related posters*

## IDNDR



Hiroo Uchiike's poster describes the operation of Japan's Tsunami Warning System

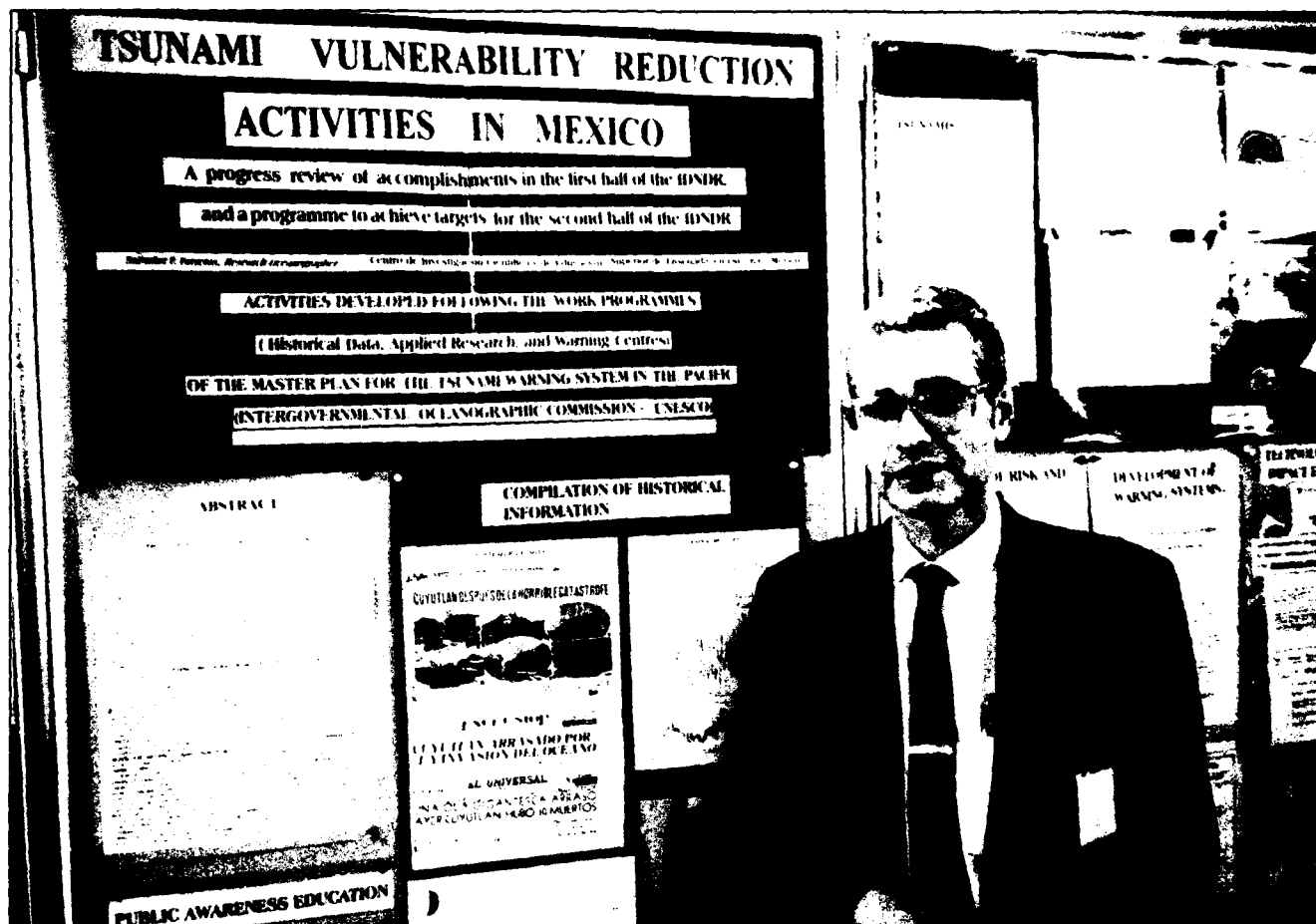
7. Vulnerability can be reduced by the application of proper design and patterns of development focused on target groups, by appropriate education and training of the whole community.

8. The international community accepts the need to share the necessary technology to prevent, reduce and mitigate disasters; this should be freely available and in a timely manner as an integral part of technical cooperation.

9. Environmental protection as a component of sustainable development consistent with property alleviation is imperative in the prevention and mitigation of natural disasters.

10. Each country bears the primary responsibility for protecting its people, infrastructure, and other national assets from the impact of natural disasters. The international community should demonstrate strong political determination required to mobilize adequate and make efficient use of existing resources, including financial, scientific and technological means, in the field of natural disaster reduction, bearing in mind the needs of developing countries, particularly the least developed countries.

Of interest to the ICG-Pacific Tsunami Warning System (in particular our ongoing educational programs and developing



Salvador Farreras (Mexico) at his poster display on Tsunami Vulnerability Reduction Activities

# IDNDR



*Emilio Lorca (Chile) presents his paper on the Pacific Tsunami Warning System to Technical Committee F*

regional warning centers), the following specific Decade strategies and activities were adopted:

- Establishing or strengthening of subregional or regional centers for disaster reduction and prevention in cooperation with international organizations and with a view to enhancing national capabilities
- Education and training in disaster prevention, preparedness and mitigation
- Promotion of regional and subregional cooperation between/ among countries exposed to the same natural hazards through exchange of information, joint disaster reduction activities and other formal or informal means including the establishment or strengthening of regional and subregional centers
- The international community should give highest priority and special support to activities and programmes relating to natural disaster reduction at the subregional or regional level in order to promote cooperation between countries exposed to the same risk
- The Trust Fund for the Decade should give priority in financing the establishment and strengthening of the early warning systems of the disaster prone developing countries particu-

larly of the least developed, land-locked, and small island developing states

Taken together with the principles, strategy and plan of action, the outcome of the Conference is recognized as the *Yokohama Strategy for a Safer World: Guidelines for Natural Disaster Prevention, Preparedness and Mitigation*. The plan itself is some 18 pages in length.

## **Megacities, Disasters and the IDNDR (Natural Hazards Observer);**

*adapted from Newsletter of the Pan American Health Organization*

By the year 2000, 28 cities in the world will have populations over eight million, and two will surpass 20 million. The effects of natural disasters on such megacities is the focus of a study - "Urban Developments and Their Vulnerability to Natural Disasters" - being conducted to further the aims of the IDNDR by the Institution of Civil Engineers, as commissioned by the Overseas Development Administration of the United Kingdom. The study will look at how megacities operate and how their infrastructures stand up to volcanoes, earthquakes, *tsunamis*, strong winds and heavy rainfall. It will examine city

# ITIC

planning, housing and other structures, communications, and services along with the health, societal, environmental, and institutional aspects of hazards vulnerability in these great metropolitan areas.

This research is intended to result in a practical guide for governments and municipal authorities regarding hazard mapping, increasing risk awareness, developing emergency response plans, and designing and engineering safer building and infrastructure. The study team is interested in receiving information and suggestions from any individuals or organizations working in this area. Correspondence should be directed to: *Louis Solway, Project Leader, Megacities Project, Institution of Civil Engineers, Great George Street, Westminster, London SW1P 3AA, UK; phone: (071)839-9770, fax: (071)233-1806.*

## ITIC

### ITIC Visiting Experts Programme for 1994

The ITSU Member States that responded to IOC Circular Letter No. 1393, ITIC Visiting Experts Programme for 1994, submitted nominations for eight visiting experts representing six different countries. ITIC plans to support the training of two experts in October-November 1994 during a four week period (see *December 1993 ITIC Newsletter*). After a thorough review and evaluation of the applications, two trainees and a first alternate were selected for this year's training session. Those nominations that were not selected will be retained for the 1995 training session.

### Associate Director Position

At ITSU-XIV, representatives from the Member States expressed interest in knowing more about the Associate Director position at ITIC that has been vacant for the last 10 years. This expression of interest is very encouraging as the Group considered an ambitious work plan for ITIC that includes a close working relationship with the ICG/ITSU Member States. ITIC is working with the Member States to encourage nomination of an Associate Director.

It is hoped that limited financial support to augment the Associate Director's living expenses in Honolulu during the (nominal) one-year assignment will be secured by IOC/ITIC. The posting of the Associate Director will become specially important if the ICG/ITSU is successful in moving ahead with the proposed Regional Tsunami Warning System in the Southwest Pacific and the ambitious ITIC work plan identified at ITSU-XIV.

### ITIC Newsletter - Mailing List Update

The ITIC Newsletter and correspondence mailing list has been converted to an improved Windows database application. All recipients of the Newsletter are reminded to verify their

mailing address and send corrections to ITIC. Newsletters that are returned to ITIC due to non-delivery will have their addresses purged.

### The INTERNET - The Mother of All Networks

*(from various media sources)*

According to research supplied at the recent Internet World '93 Conference in Manhattan, New York, the Internet is attracting some 150,000 new users each month with a combined overall user population estimated at 15 million or more. The Internet itself links 1.7 million computers in more than 135 nations around the world. Developed out of a U.S. Defense Department network of the 1970s, the Internet has grown beyond users in the scientific/research community to include corporations, the media and home users. The Internet used to link together a small number of users but now faces growth of 8% every month(!), creating numerous changes (and access headaches!) for a rapidly expanding network.

The Internet is a developing on-ramp to the *information superhighway*. For the international tsunami community, it provides a pathway to communicate with each other, share information and stay in-touch with a growing community of *many other* users around the world. With access to the PMEL-sponsored Tsunami Bulletin Board, ITIC has found the network indispensable for communicating with colleagues, sharing data files, and accessing a rich set of information sources around the world.

### INTERNET Address Corrections and Additions

Please make note of the following Internet address changes:

ITIC's Internet address has been changed to:  
**itic@ptwc.noaa.gov**

Papeete, Tahiti, Laboratoire de Geophysique,  
Dr. Francois Schindele (LDG, Head):  
**schindele@ldg.bruyeres.cea.fr**

Please make note of the following Internet address change at PTWC, for general operational matters:  
**ptwc@ptwc.noaa.gov**

### Tsunami Information Resource Service

Through the efforts of ITIC, the Tsunami Information Resource Service brings together a number of prominent tsunami experts specializing in seismology, tsunami generation, historical tsunami accounts, tsunami hazard assessment, and tsunami modeling. Along with ITIC, these experts are donating their time and expertise to promulgate knowledge and awareness on tsunamis and the hazards they present. This service will function primarily to answer questions from the media about



## NATIONAL AND AREA REPORTS

tsunamis with the objective of improving awareness of this often misunderstood natural hazard. Questions from the media are frequently received when a tsunami has occurred somewhere in the Pacific or when a tsunami alert has been issued locally. Initially, the service is intended to serve the media in Hawaii. It is foreseen to be expanded to the mainland U.S. and Alaska in the future. This service can also be viewed as a model for other countries in developing a resource pool of tsunami experts to answer tsunami-related questions from the media and public.

Please contact ITIC for further information if you are interested in participating in the service, inquiring about the service as a media user, or are interested in establishing the service in your country or geographical area. *It is important to note that when a tsunami warning has been issued, local disaster preparedness authorities will be responsible for evacuating low-lying areas susceptible to tsunami inundation. Information provided by this service is in no way intended to replace or supersede tsunami warning bulletins and/or evacuation orders issued by national/regional warning centers and/or local preparedness authorities.*

### A Note from the Acting Director

Dr. George Pararas-Carayannis, ITIC, suffered a heart attack in late February and is doing well following corrective surgery. George remains professionally active as a consultant involved with tsunami and other natural hazard mitigation projects.

### Visitors to ITIC, December 1993 through June 1994

With winter and associated cold weather in the northern temperate latitudes, ITIC saw a number of visitors stop-by the office beginning in late November.

Lieutenant William Sites, National Weather Service Headquarters (Silver Spring, Maryland) spent the week of December 3 involved in an internal (NWS) tsunami coordination meeting and working visit at ITIC. In cooperation with the NWS, ITIC has completed an updated version of the brochure "TSUNAMI! The Great Waves." The revised brochure focuses on tsunami awareness and hazard mitigation and is available to the public through the ITIC and NWS. Lt. Sites handled coordination for the brochure's preparation within the NWS. Lt. Sites was accompanied by his wife, Kelly, who enjoyed the tropical Hawaiian climate and the opportunity to shop at the Ala Moana Center.

Mr. Richard Hutcheon, Director - NWS Alaska Region, and Mr. Thomas Sokolowski, Geophysicist-in-Charge at the Alaska Tsunami Warning Center, visited ITIC on December 4, in conjunction with an internal (NWS) tsunami coordination meeting.

Mr. James Lander and his lovely wife Corinne visited ITIC on December 10. Mr. Lander, former Director of the World Data Center A for Solid Earth Geophysics, is working on a new publication, *Tsunamis Affecting the West Coast of the United States: 1806-1992* (see related article). While visiting in Hawaii, he collected data and other information for the publication.

Mickey Moss, Jim Russell and Jim Bosshardt, of the National Ocean Service's Pacific Operations Group visited with the Acting Director, ITIC, (January) in conjunction with their annual trip to inspect and perform maintenance on Hawaiian Island tide gauge systems.

Mr. Lionel M. Stevens, National Civil Defense Controller - New Zealand, visited ITIC on February 23, in conjunction with meetings at Hawaii State Civil Defense and Mike Blackford, GIC - PTWC. The ITIC Acting Director and Mr. Stevens discussed tsunami education and preparedness planning and reviewed recent destructive tsunamis in Japan, Indonesia and Nicaragua. Mr. Stevens presented the ITIC Library with a wonderful pictorial publication on New Zealand as well as educational and preparedness materials (for natural hazards) prepared by the Ministry of Civil Defense, New Zealand. Details and course curriculum related to the IOC-sponsored Visiting Experts Program was also discussed.

Dr. Susan Zevin, Director of the National Weather Service's (NWS) Eastern Region, visited ITIC in conjunction with her travel to the NWS Director's meeting in Honolulu.

### ITIC - On the Move

Within the next six months, the ITIC office and library are expected to relocate (along with the Pacific Region Headquarters of the National Weather Service) to a new location in downtown Honolulu. We are being asked to move due to space limitations in our present building and the need to accommodate a new tenant. It is not certain at this time if our phone numbers will change; we will have a new mailing address. The December 1994 ITIC Newsletter will have an update on our move.

## NATIONAL AND AREA REPORTS

### Preliminary Report, 1994 East Java Indonesia Earthquake and Tsunami

*The following (edited) preliminary report on the June 3, 1994, Java earthquake and tsunami was submitted by F. Imamura (Japan) on June 27, 1994.*

An International Tsunami Survey Team (ITST) comprised of engineers and scientists from Indonesia, Italy, Japan, United States and Thailand was organized to investigate damage and measure tsunami runup following the tsunami of June 3, 1994,

## NATIONAL AND AREA REPORTS

along the Indian Ocean coastline of Java and Bali islands. Field investigations were carried out between June 20 - 25 along the coastline from west Bali Island to Prigi, Trenggalek and the middle area of Java Island. Thirty-two team members were involved in the ITST survey work.

A numerical simulation of the June 3 tsunami was run by Prof. N. Shuto and Mr. T. Takahashi (Tohoku University, Japan) using fault parameters provided by the Harvard CMT. Computed results indicate the tsunami heights using the Harvard CMT are much less than the 10+m runup measured at some villages in the Pesanggaran district. The purpose of the field survey was to quantify the runup heights, arrival times, and tsunami characteristics to better understand the generation and amplification mechanism. In regard to human factors, the team investigated why (after the experience of the 1992 Flores Island tsunami) there were so many casualties and destruction of many structures (mainly houses).

Based on the number of casualties and destruction to coastal villages, it was recommended at a post-survey discussion to relocate houses near the coastline to higher ground and develop a community-based local tsunami warning capability. The survey team encountered heavy erosion along the coast caused by the tsunami. Examples of the erosion were widely observed at Pancer, Rajekwesi in Bagyuwagi and Gerangan in Tulugagung. A maximum erosion depth of more than 1.5m was measured at Rajekwesi. Erosion near the coast and deposition inland were clearly found on Sempu Island.

### Preliminary Tsunami Runup Measurements

*(in meters, with no tidal correction)*

Location	Runup
West Bali	1.03 - 4.45
Pancer	6.10 - 9.50
Rajekwesi	4.66 - 13.27
Triangwul	5.75
G-land (8.7S 114.3E)	3.35 - 5.65
Bandialet	5.55 - 11.30
Tambakrego, Blita	2.85 - 4.50
Sine	2.78 - 3.50
Popoh	2.15 - 3.0
Pantai	4.17
Sendangbru	2.36 - 4.03
Sempu Island	2.36 - 2.76
Gerangan	5.21 - 5.31
Brumburn	4.23 - 5.21

### Chile to Install TREMORS System

The Government of Chile has committed the Hydrographic and Oceanographic Service of the Chilean Navy to improve the Chile National Warning System by supporting the acquisition and installation of the TREMORS system in 1994. TREMORS (Tsunami Risk Evaluation through seismic MOment from Real time System) is an integrated automatic system, based on a three-component broadband seismic station developed by the Laboratoire de Geophysique to compute in real time the earthquake source parameters and provide a quantitative estimate of tsunami risk.

### Tsunami Education and Awareness Program

#### ... in the USA (Hawaii)

Dennis Sigrist, Acting Director, ITIC, and Dr. Dan Walker, University of Hawaii, met with Ms. Colleen Murakami, Hawaii Department of Education, in December to discuss tsunami education and awareness planning. In support of a trial education and awareness program, ITIC is providing copies of the children's booklet "*Tsunami Warning!*" and a supplemental workbook for use by the Department of Education. These materials will be made available to the Department of Education for distribution to elementary schools statewide in Hawaii. Dennis Sigrist, Dr. Walker and Bruce Turner (PTWC) also conducted Tsunami Workshops for 6th grade teachers and students on the islands of Oahu, Maui, Kauai, and Hawaii as part of the program. Ms. Murakami and the Department of Education have been very supportive of this effort. With school on summer break, the Tsunami Workshops are expected to resume this fall.

#### ... in Chile

Chile's Hydrographic and Oceanographic Service has completed the publication of a series of earthquake and tsunami related textbooks for children of pre-school age through high school. A ceremony was held on May 13, 1993, at the main Navy Conference Center in Valparaiso where the tsunami textbooks and an oceanographic atlas were presented to national education authorities. During the ceremony, attended by Chile's Chief of Naval Operations, educators, and the media, Hugo Gorziglia (ICG/ITSU Chairman) spoke on the development of the textbooks and the goal of educating children to reduce the loss of life from tsunamis. Chile has set a high priority to distribute the text books, initially, to schools in the northern part of the country. Copies of the textbooks and teacher guide books were available at the IOC display during the IDNDR Meeting in Yokohama.

### Tsunami Inundation Modeling Project

In the United States, NOAA is the primary agency responsible for tsunami warnings and hazard mitigation. Together with

## NATIONAL AND AREA REPORTS

tsunami warning information (estimated tsunami wave arrival time), NOAA is developing a plan that would provide basic information and products to communities to help mitigate the loss of life and destruction of property caused by tsunamis. The most fundamental tool for these mitigation activities is an accurate tsunami inundation map. A tsunami modeling workshop was hosted by NOAA's Pacific Marine Environmental Laboratory (PMEL) in November 1993 to discuss tsunami modeling technologies and the requirements of emergency managers and preparedness officials for inundation maps.

The primary goals of the project is to mitigate the tsunami threat to Hawaii, California, Washington, Oregon and Alaska. This will be accomplished by conducting research on tsunami generation, propagation, and inundation dynamics aimed at improving NOAA hazard mitigation products. The first, preliminary product from this research, an integrated seismic/tsunami hazard map for Eureka, California, has been developed for a near-field, locally generated tsunami. (Reference: *Tsunami Inundation Modeling Workshop Report, NOAA/PMEL January 1994*)

### Low-cost Tsunami Recording Instrument

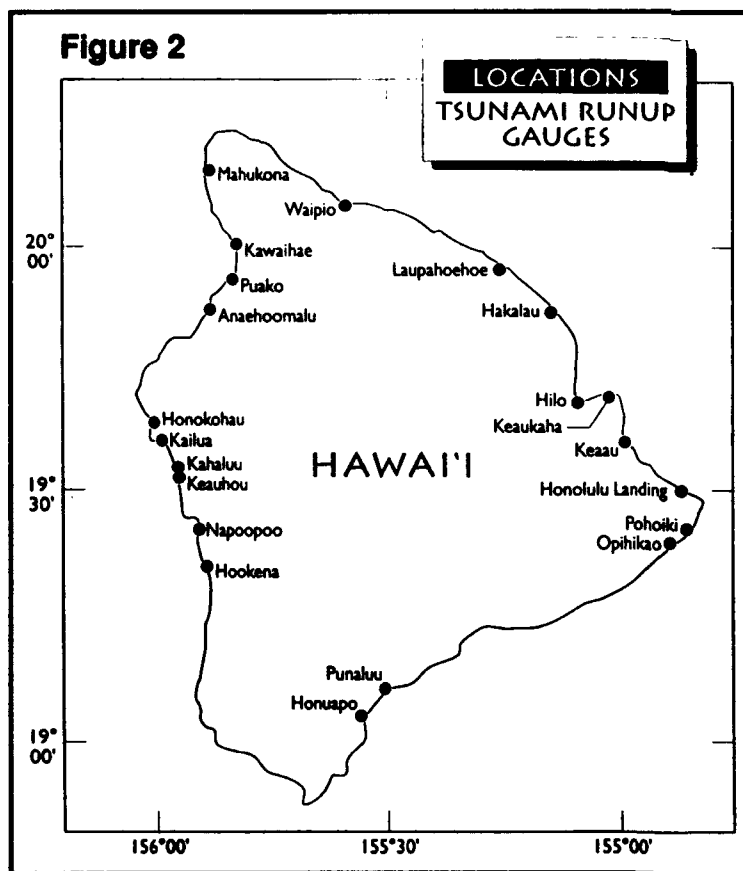
Dr. Dan Walker, with the University of Hawaii - School of Ocean and Earth Science and Technology, has developed a low-

cost tsunami runup gauge. The gauges are made from lengths of rectangular-shaped extruded plastic and are attached to trees and poles in expected tsunami inundation areas. In March 1994, the Island of Hawaii was instrumented with the low-cost, land-based tsunami runup gauges. A total of 26 stations were deployed at 21 locations around the island. Station locations are indicated in figure 2. An example station, attached to a coconut palm tree, is shown in the accompanying photograph. Depending on tidal conditions and station locations, runups of less than 1 meter to more than 10 meters could be recorded by these instruments. The Island of Hawaii is the first in a state-wide program to provide more precise and comprehensive measurements of runups for future tsunamis.

### PEACESAT Telecommunication Service

(From The Pacific Island Network Newsletter, Pinpoint Winter 1994)

The Pan-Pacific Education and Communication Experiments by Satellite, or PEACESAT, is a valuable resource for Pacific basin service organizations. It provides free telecommunication services, between 36 sites in 25 countries, for educational and medical purposes. PEACESAT started operations in 1971 using the National Aeronautics and Space Administration (NASA) Applications Technology Satellite (ATS-1) to provide



Low-cost tsunami runup gauge attached to coconut palm tree (Island of Hawaii); engraved unit measurements are at 20 cm. interval

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a simple push to talk voice channel for regional teleconferencing. In mid-1985 the ATS-1 satellite ran out of station-keeping fuel and drifted away from its position over the Pacific, thus services were curtailed. However, the ongoing success of PEACESAT let the U.S. Congress to appropriate money, through the National Telecommunications and Information Administration, in order to re-establish a revitalized PEACESAT. NOAA re-positioned one of its weather satellites, the GOES-3, for PEACESAT's use and in the early 1990s new low cost ground stations were installed. PEACESAT was re-born with a greater array of services.

Current PEACESAT communications equipment includes nine simplex, or push to talk, voice channels and three duplex or two way channels. The duplex channels can accommodate computerized data transmission. The ground stations, developed by a New Zealand company, are self-contained and include a modem, a device that allows for data transmission from computers. In support of increased computer use of PEACESAT facilities, the Hawaii headquarters has set up a computer bulletin board to provide scheduling information and electronic mail service and to facilitate the transfer of data files. PEACESAT is also now linked to the University of Hawaii computer network and through it to the world-wide Internet network.

What lies in the future? A recent survey of PEACESAT users' needs suggests that computer communication will become more prevalent, necessitating an increase in the number and speed of circuits for data transfer. There is also an interest in video teleconferencing. However, special technologies will have to be employed to reduce the amount of information that must be sent to assemble a video image. PEACESAT can currently transmit slow scan-still video images. Future advances may allow the transmission of compressed video. This technology would enable users to set up more sophisticated video teleconferences.

Extension organizations may enter a new era as electronic communications allow more sophisticated and 'life-like' interaction. Instead of a person traveling to multiple sites to conduct a workshop for example, the participants could be able to see and hear each other over an electronic telecommunications link. While not a complete substitute for personal interaction, these new forms of distance education are well suited to the special geography of the Pacific.

## ANNOUNCEMENTS Meeting Reports

### **Seismological and Tsunami Hazards in the Pacific, IASPEI '94 Workshop, 10 January 1994, Convenors: R.D. Adams (UK), W.D. Smith (New Zealand)**

*Meeting report kindly provided by Warwick Smith*

This workshop was held on the first day of the Assembly, and the planned programme was somewhat curtailed by the delayed arrivals of some contributors. Nevertheless, a lively session was held, with seven full presentations, and five displays, of which four were supported by brief oral presentations. The programme started with general considerations and later moved to more specific studies.

The first presentation, by D. Giardini and others, reviewed the progress of GSHAP in East Asia, Western Pacific Region. G.F. Panza was unable to present his paper describing three-dimensional modeling of the Earth's tecto-sphere, and its relation to hazard assessment, but this was discussed at a later session of the Committee for Developing Countries. R. Valenzuela and colleagues showed how careful re-evaluation was needed to assess the reliability of intraplate seismicity in the Pacific, and that a significant number of such earthquakes could be associated with bathymetric and tectonic features. W.D. Smith pointed out differences found in New Zealand in attenuation patterns for upper and lower crustal events, and the need for special consideration in estimating hazard near subduction zones. L-1 Xue described a probabilistic method used to produce a new zoning map of China, incorporating their long historical record of earthquakes and information from tectonics. In the first paper relating to tsunamis, S. Barientos and colleagues showed how analysis of tsunami effects of great historical earthquakes in Chile can be used to estimate rupture parameters leading to derivation of moment magnitude. D.C. Jepsen then described tsunami observations made in Australia from the large Macquarie Ridge earthquake of 1989.

The strongest tsunami excitation is from earthquakes with thrust-type mechanism, but despite having a mechanism of strike-slip type, this earthquake generated tsunami amplitudes of about two-thirds of a meter in Tasmania. In the final scheduled oral presentation, E. Spassov described a hazard-evaluating algorithm derived from geophysical and structural parameters. F. Guendel then elaborated on his poster describing the work of the newly established Regional Data Center in Guatemala, which has resulted in a very significant increase in Central American Seismological data reaching international agencies. A poster depicting geophysical studies across the Canadian west coast was described by R.D. Hyndman. The geometry of the offshore thrust is likely to limit the ground motion amplitude at sites in the Canadian coast. In the final

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presentation T.L. Teng described the extremely dense strong motion areas in Taiwan. In addition, arrays of up to 30 channels in individual buildings enable their vibration characteristics to be determined, and detailed response to be monitored during earthquakes excitations. J.M.W. Rynn presented a poster applying seismological and geophysical techniques to produce zoning maps in three urban areas of Australia.

There was thus a wide variety of topics from authors from many different regions, reflecting the diversity of seismological regimes and problems in the Pacific. It was disappointing, however, that there were no participants from Southeast Asia or the islands of Oceania. Nevertheless, the discussions were able to show that there is much to be gained by exchanging data, techniques and results from around the Pacific, with difficult techniques being adjusted to fit local conditions.

## Tsunami Session, Seismological Society of America

*Meeting report kindly provided by Kenji Satake*

There was a special session on Tsunamis at the 89th annual meeting of the Seismological Society of America, April 5-7, 1994 in Pasadena, CA. The meeting format was unique; all the papers in the meeting (about 250) were in poster format with short (2-minute) oral introductions. Because the posters were presented for two days, there was enough time for in-depth discussion.

The following 12 papers were in the Tsunami session; the abstracts are found in *Seismological Research Letters*, volume 25, number 1, pages 24-26, 1994.

- Mechanism of the 1992 Nicaragua "tsunami" Earthquake by Satake, K.
- Modeling the Seismic Source and Tsunami Generation of the December 12, Flores Island, Indonesia, Earthquake by Hidayat, D., J.S. Barker, and K. Satake
- Moment Release of the 1992 Flores Island Earthquake Inferred from Tsunami and Seismic Data -by Imamura, F. and M. Kikuchi
- The 1993 Southwest Hokkaido Earthquake and Tsunamis -by Tanioka, Y. and K. Satake
- Two 1993 Kamchatka Earthquakes; Standard and Tsunami Events -by Johnson, J.M., Y. Tanioka, K. Satake, and L.J. Ruff
- Water Waves Generated by Underwater Landslides by Watts, P. and F. Raichlen
- Numerical Computation of Tsunamis from Hypothetical Cascadia Earthquakes -by Satake, K.
- Temporal Variation in Response of San Francisco and San Diego Bays to Tsunamis -by Tanioka, Y. and K. Satake

- Potential Source of Local Tsunami in the California Continental Borderland -by Legg, M.R.
- Numerical Study of Runup of 1992-93 Tsunami Events -by Titov, V.V. and C.E. Synolakis
- Tsunami Source Mechanism Related to Tectonic Regimes -by Lander, J.F.
- Measurements of Tsunami Run-up on a Circular Island -by Briggs, M.J., C.E. Synolakis, G.S. Harkins, U. Kanoglu and A. Collidge

## Eastern Asia Hazards Mapping Project

*as reported by Dennis Sigrist, ITIC  
and Hirokazu Kato, GSJ*

An informal progress meeting to discuss the Eastern Asia Hazards Mapping Project was convened by the Geological Survey of Japan on Wednesday, May 25 in Yokohama, Japan. The hazard mapping project is complimentary to the goals and recommendations of the International Decade for Natural Disaster Reduction.

Asian countries have seen in recent years the severe damage, not only in the industrial infrastructure, but in the loss of life and homes due to the frequent occurrence of many different kinds of natural disasters. Losses have continued to increase due to rising population densities and insufficient policies to meet the intensifying demand to develop in areas that are susceptible to natural disasters. In order to mitigate those damages, it is necessary to investigate natural disasters that have happened in the past and to make an assessment of the potential for such hazards to occur in the future. For the purpose of educating the population and providing important guidance to policy makers, it is useful to compile hazard maps and related database of disasters.

The goal of the project is to compile small-scaled (1:5,000,000) hazard maps. Working with the countries of eastern Asia, the Geological Survey of Japan is aiming to map geological hazards such as earthquakes, volcanic eruptions, landslides, tsunamis, and coastal erosion in eastern Asia and Japan. Dr. Hirokazu Kato, Chief of the GSJ's Overseas Geology Section, is the project leader. The first in a series of Working Group Meetings (*Project Workshops*) is scheduled to be held in Tsukuba on September 6-8, 1994, to discuss the technical problems of hazards mapping.

The project was originally proposed in 1992 at the international forum "Hazard Mapping Project" in Tsukuba City, Japan, in cooperation with other countries conducting related activities. The final hazard maps are expected to be published in 1997 and will be made available for distribution to interested users. Dennis Sigrist, Acting Director of ITIC, attended the May 25th progress meeting in Yokohama. Ms. Wen Baopin and Dr. Yang Huating (China), Dr. Irwan Bahar (Indonesia),

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Dr. R. S. Punongbayan (Philippines), and Dr. H. Kato (Japan) reported on their respective national mapping projects at the progress meeting. Dr. Takeo Sato, Director General of the Geological Survey of Japan, hosted the progress meeting in Yokohama, while Dr. Yukio Togashi served as chairman.

## Western Pacific Geophysics Meeting - Hong Kong, July 25-29

*Meeting information kindly provided by Kenji Satake*

The Following papers have been accepted for presentation at the Western Pacific Geophysics Meeting - Hong Kong, July 25-29, 1994:

### SE41A (Morning, Thursday July 28): Tsunamis in the Western Pacific Region

- "A Family of N-waves for Modeling Tsunami Run-up"  
by Tadepalli and Synolakis (Ref # 5013)
- "The 1640 Komagatake Tsunami Runups as Revealed by the  
Tsunami Deposits"  
by Nishimura and Miyaji (Ref # 5407)
- "Effect of Fallen Snow on Run-up Processes of the 1923  
Kamchatka Tsunami"  
by Minoura, Gusiakov and Svendsen (Ref. # 5208)
- "Two 1993 Kamchatka Earthquakes: Standard and Tsunami  
Events"  
by Johnson, Tanioka, Satake, and Ruff (Ref # 5376)
- "Study on the 1992 Tsunami in Eastern Flores Island,  
Indonesia, by Numerical Simulation"  
by Imamura, Takahashi and Shuto (Ref # 5034)
- "Modeling the Seismic Source and Tsunami Generation of  
the December 12, 1992 Flores Island, Indonesia, Earth-  
quake"  
by Hidayat, Barker and Satake (Ref # 5371)
- "Damages of the Indonesia-Flores Earthquake-Tsunami of  
December 12, 1992"  
by Tsuji, Takeo, Imamura, Takahashi, Matsutomi,  
Kawada and Matsuyama (Ref # 5247)
- "Tsunami Source Model of the 1993 Mariana Earthquake"  
by Abe, Kuniaki (Ref # 5353)
- "Tsunami Excitation and Mechanism of the Guam Earth-  
quake, August 8, 1993"  
by Tanioka, Satake and Ruff (Ref #5435)
- "Pacific Tsunami Warning Center: Modernization of  
Methods and Mission"  
by McCreery, Blackford, Cessaro, Wessel, Turner and  
Mass (Ref # 5399)

### SE42A (Afternoon, Thursday July 28th) 1993 Hokkaido Nansei-Oki Earthquake Tsunami

- "The 1993 Southwest Hokkaido Earthquake and Tsunami"

by Satake and Tanioka (Ref # 5418)

- "The Estimation of the Fault Parameters of the 1993  
Hokkaido Nansei-Oki Earthquake and Characteristics of  
the Tsunami"

by Kato and Tsuji (Ref # 5246)

- "Initial Profile of the 1993 Hokkaido Nansei-Oki Earthquake  
Estimated with the Tide Record Inversion"

by Take Takahashi, Tomo Takahashi, Imamura and Shuto  
(Ref # 5432)

- "Numerical Simulation of the 1993 Hokkaido Nansei-Oki  
Earthquake Tsunami"

by Tomo Takahashi, N. Shuto, M. Ortiz and F. Imamura  
(Ref # 5433)

- "A study of the July 12, 1993 Hokkaido-Nansei-Oki Tsu-  
nami Using a 3-D Runup Model"

by Titov and Synolakis (Ref # 5054)

- "Spectral Analysis of the Hokkaido Nansei Oki Tsunami of  
July 12, 1993"

by Arai, Kosuga and Tsuji (Ref # 5248)

- "Characteristics of Tsunami on the East Coast of Korea,  
Caused by Hokkaido Earthquake July 12, 1993"

by Oh, Lee and Rabinovich (Ref # 5476)

- "Post-tsunami Okushiri Aerial Photography"

by Gonzalez (Ref # 5369)

- "What a Hazardous Impact was at Aomae Harbor in July  
1993" (publication only)

by Nakamura (Ref # 5100)

## POSTERS

- "Side Scan Sonar Images, Southwest off Hokkaido, 1993  
Earthquake Site Obtained by IZANAGI system"

by Yamamoto, Suyehiro, Tokuyama, Taira and Okino  
(Ref # 5445)

- "Discovery of the Past Big Tsunami Earthquake Event  
Before the 1993 Hokkaido Nansei-Oki Earthquake, South-  
west Hokkaido, Japan"

by Toda and Inoue (Ref # 5505)

## Upcoming Meetings

### Symposium on Tsunamis in Athens, Greece, 23 September 1994

*Convenor: Stefano Tinti*

A Symposium on Tsunamis will be held in Athens in the framework of the European Seismological Commission (ESC) XXIV General Assembly (19-24 September 1994). The symposium is entitled "Tsunamis in the European Countries" and will take place on Friday September 23rd.

All theoretical, experimental and modeling aspects of tsunamis will be taken into account as well as historical studies.

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Though emphasis will be given to tsunamis affecting Europe, the symposium is open to papers on events in any part of the world. Deadline for sending abstracts was June 15, 1994.

## **International Conference on Disaster Reduction in the Coastal Cities, Beijing, China, October 4 - 7, 1994**

The International Conference on Disaster Reduction in the Coastal Cities is hosted by the China Association for Science and Technology and is supported by the IDNDR, WMO, UNESCO and the IOC. The conference is planned as a high level scientific meeting which will review the current state of knowledge and the many aspects of disaster reduction of coastal cities. It will also provide an opportunity for the exchange of new ideas, achievements, experiences and innovative techniques in the theoretical and practical areas in this field. Prof. Liu Shu is the Organizing Chairman of this conference.

## **Geological Society of America, October 24-27, 1994**

The Geological Society of America (GSA) will hold its 106th Annual Meeting and Exposition in Seattle, Washington, USA, during the period Of October 24 -27, 1994. This year's theme will be "On the Leading Edge." The GSA's membership includes some 17,00 professionals, dedicated to the advancement of the science of geology and to supporting the efforts of earth scientists.

## **IUGG International Tsunami Symposium, July 1995, Boulder, Colorado**

The Tsunami Commission's 17th International Tsunami Symposium, will focus on research that leads to disaster reduction. The themes of the symposium are (1) historical and contemporary observations of tsunamis, (2) physical processes of tsunami evolution, and (3) hazard reduction through assessment techniques and warning systems. All interested scientists are invited to contribute. Lead Convenor is Dr. Eddie N. Bernard, PMEL; Seattle, Washington.

The Tsunami Commission is seeking applicants to edit the book that will be published by Kluwer Academic Publishers of selected papers from the 1995 International Tsunami Symposium to be held in Boulder, Colorado. Two books have been published on selected papers from the 1989 and 1991 Symposia and a third is in preparation from the 1993 Japan (Wakayama) Symposium. The Tsunami Commission has acted as a facilitator in seeking an editor and the cooperation of authors. Professor Stephano Tinti, who edited the book *TSUNAMIS IN THE WORLD*, suggested that an editor be identified before the 1995 Symposium. To apply for the editor position, contact Dr. Eddie Bernard; email [bernard@pmel.noaa.gov](mailto:bernard@pmel.noaa.gov), FAX (206) 526-6815, voice telephone (206) 526-6800. Application deadline is August 1, 1994.

## **Fifth International Conference on Seismic Zonation, October 17-19, 1995**

The French Association for Earthquake Engineering (AFPS) and the Earthquake Engineering Research Institute (EERI) have announced the co-sponsorship of an international, multidisciplinary conference on Seismic Zonation, to be held in Nice, France. The conference will provide state-of-the-art assessment of the advances in seismic zonation integrating earth sciences, engineering, planning, social sciences, and public policy. The venue will be the Acropolis Congress in Nice, France, October 17-19, 1995. The program will include multidisciplinary discussions of how seismic zonation has been used as a tool in mitigation efforts in major seismic regions throughout the world. A call for papers has been issued and the deadline for submitting abstracts was June 1, 1994. For more information contact the EERI at:

499 14th Street, Suite 320  
Oakland, California  
94612-1902

## **Hazards '96 Conference**

A decision was made at the Hazards '93 Conference, held last year in Qingdao, China, to convene the Hazards '96 Conference in the United States. This will be the sixth in a series of international conferences addressing natural and man-made disasters. The Natural Hazards Society served as the primary sponsor of the China conference and will be the primary sponsor of Hazards '96. Although the site for the conference has not been determined, it has been noted that Washington, DC, would be a good possibility because of the large number of agencies interested in hazards. Follow-up information on Hazards '96 will be presented in future editions of the ITIC Newsletter.

## **TSUNAMI 1996**

Marking the 50th anniversary of the devastating 1946 tsunami at Hilo, Hawaii, which led to the development of the present Pacific Tsunami Warning System, and noting the centennial of the great Sanriku earthquake and tsunami in Japan, an educational and awareness conference is planned for Hilo on April 1-2, 1996. The conference will review the lessons learned, progress that has been made, the projects still to be accomplished, and priorities for tsunami and similar hazard mitigation strategies. An open house and tour of the Pacific Tsunami Warning Center on Oahu will be available on the following day. The co-chairs of the Conference are Jim Lander (formerly of NGDC) and George Curits (University of Hawaii at Hilo)

## **30th International Geological Congress, August 1996**

The 30th International Geological Congress (IGC), hosted in part by the Geological Society of China and the Ministry of

# ANNOUNCEMENTS

Geology and Resources of China, is scheduled to take place in Beijing, China, during the period of August 4-14, 1996. The 30th IGC will focus on continental geology with emphasis on the continent-related tectonics and structures, energy and mineral resources, environmental protection, and geological hazards reduction as well as their interrelationship with human survival and sustainable development. A large number of program-related field trips has been planned for participants to show the characteristic features of continental geology in China. The first announcement circular has been distributed requesting return of the preliminary questionnaire by October 31, 1994.

## **Pure and Applied Geophysics - Call for Papers**

To document recent tsunamis such as in Nicaragua, Indonesia and Japan, and developments in related research, Pure and Applied Geophysics will publish a topical issue on recent (1992-3) tsunamis. The goal of this issue is a comprehensive documentation of recent earthquake tsunamis, and presentation of data as well as research results. Papers covering tsunami field survey data, tectonics and seismological analysis of the earthquake, tsunami numerical computations, and physical experiments directly or indirectly related to recent tsunamis are invited.

There will be no page charges for the papers in the topical issue. Simultaneously, with the journal issue, an inexpensive soft-cover book edition will be published from Birkhauser Verlag. The Papers (English only, in triplicate) should be submitted to either editor by August 1, 1994. Please inform one of the editors about your interest and a tentative title of the paper.

Editors: Kenji Satake

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Manuscripts must be submitted in triplicate, typewritten with double line spacing and wide margins, on 8 1/2" x 11" paper. Copies of the figures should be attached at the end of the manuscript. Original, high-quality, glossy figures may be submitted later. All manuscript pages, including references, tables, and captions, should be numbered consecutively, starting with the title page as page one.

## **Just Published**

### **TSUNAMI! The Great Waves**

In cooperation with NOAA/NWS, ITIC has published a completely revised version of the tsunami educational brochure, *TSUNAMI! The Great Waves*. Originally released in 1975, the original brochure was not contemporary and in need of a major face lift. Focusing on a public education and hazard awareness theme, the new multi-color brochure provides a brief background and history on tsunamis but with a major emphasis on safety facts and hazard mitigation. Copies of the brochure are available from the NWS and at ITIC.

### **Expected Tsunami Amplitudes & Currents Along the North American Coast for Cascadia Subduction Zone Earthquakes, Paul M. Whitmore, Alaska Tsunami Warning Center**

This paper summarizes the tsunami potential for three hypothetical Pacific Northwest earthquakes. The study found that tsunami heights along the northwest US coast will be up to 6 m above the mean sea-level. Elsewhere along the North America coast wave heights will be significant lower. Originally published in *Natural Hazards* 8 59-73, 1993, Kluwer Academic Press.

### **The Cape Mendocino Earthquake: A Local Tsunami Wakeup Call? R. McCarthy, E. Bernard, & M. Legg. Coastal Zone 1993.**

**Condensed abstract:** Sudden displacement of the seafloor due to fault offset or submarine slumping can generate tsunami waves that can travel vast distances across open ocean and damage coastal communities.

Local tsunamis generated by faults located in offshore California waters, the sudden uplift of a large land mass due to faulting, or the downslope displacement of large areas due to slumping in submarine canyons can strike the coastline within <10 minutes. This paper describes the Cape Mendocino earthquake and its uniquely large aftershocks, discusses the potential near-shore tsunami sources for offshore California, and presents some recommendations on how to establish tsunami risk mitigation for coastal California.

### **Geologic Hazards Slide Sets and CD-ROM**

Twenty-five unique sets of 35-mm slides depicting geologic hazards throughout the world are available from the National Geophysical Data Center (NGDC). Each slide set consists of 20 slides in color and/or black and white. Included with the slides is documentation that provides the background material, dates, locations, and descriptions of effects for the depicted hazards. These slide sets provide an affordable tool for presentation to both technical and non-technical audiences.



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The tsunami slide set depicts advancing waves, harbor damage, and structural damage from seven tsunami events which have occurred since 1946 in the Pacific region. As part of a data preservation effort, the natural hazard photographs have been digitally scanned and replicated on a two-volume CD-ROM set. The images can be imported into many standard software packages. MS Windows-based access software, for PCX images only, is provided. For further information, contact NGDC at 325 Broadway, Boulder, Colorado 80303 USA; FAX: 303-497-6513; INTERNET: [info@mail.ngdc.noaa.gov](mailto:info@mail.ngdc.noaa.gov).

### **Tsunamis Affecting the West Coast of the United States, 1806-1992**

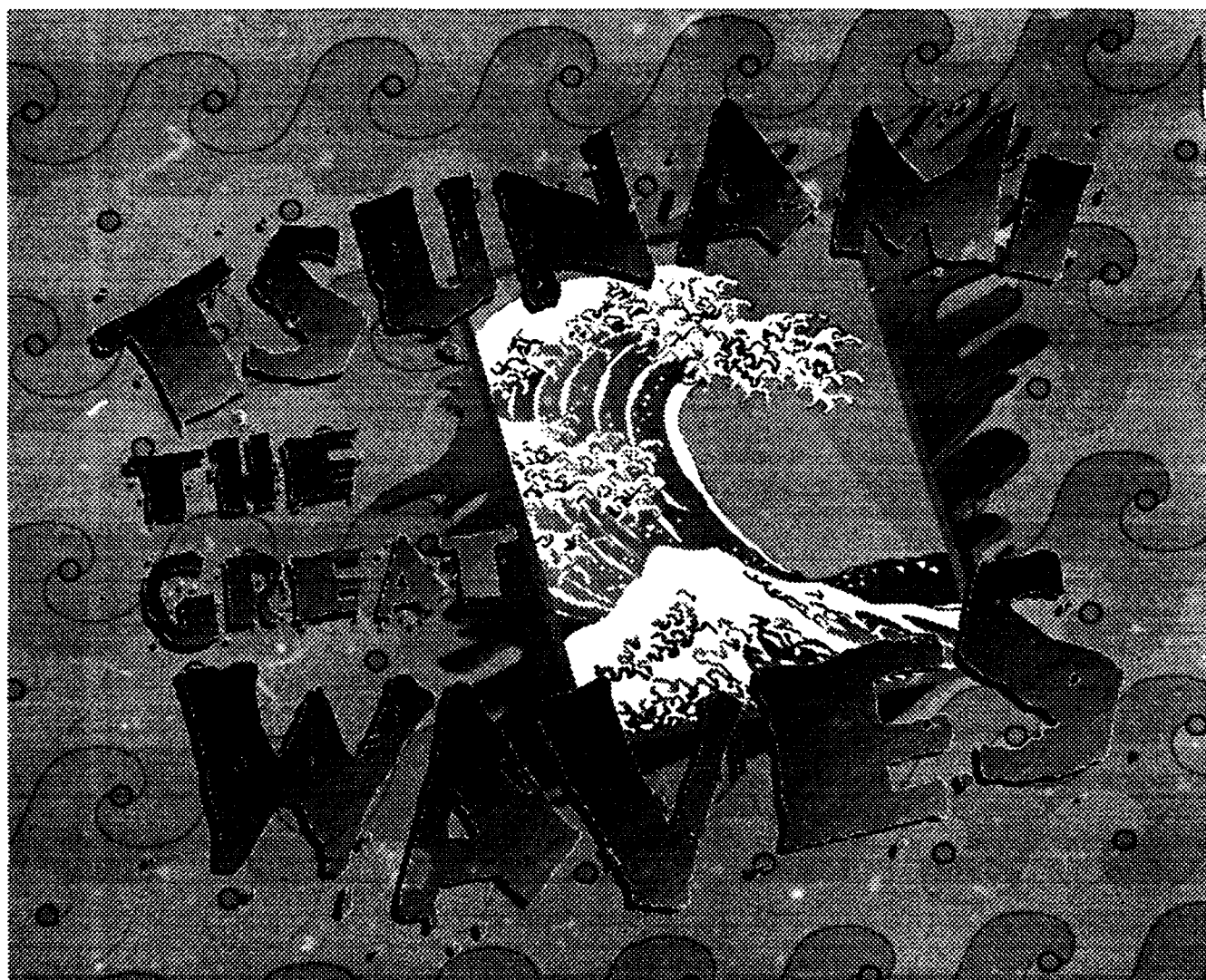
*Tsunamis Affecting the West Coast of the United States 1806-1992* (by J. Lander, P. Lockridge, and M. Kozuch, 1993) builds on the section treating the west coast in *United States Tsunamis, 1690-1998* (by J. Lander and P. Lockridge, 1989). This new version substantially increases the amount of data, number of

events, and their evaluation. As before, detailed description information is included to better characterize the tsunami hazard. The text is illustrated with pictures, tables, marigram records and other figures. Available in hard or soft cover; National Geophysical Data Center, Boulder, CO. FAX: 303-497-6513, Internet: [info@mail.ngdc.noaa.gov](mailto:info@mail.ngdc.noaa.gov)

### **Propagation of Hokkaido Nansei-Oki Tsunami Around Cape Aonae, Okushiri Island**

*S. Tanaka, S. Sato and K. Noguchi; Coastal Engineering Division, Public Works Research Institute, Ministry of Construction (Japan)*

The Hokkaido Nansei-Oki earthquake rocked the west coast of Hokkaido and Okushiri Islands on July 12, 1993. It caused a devastating tsunami which quickly hit Okushiri Island and the west coast of Hokkaido. Because the tsunami source area was



## ANNOUNCEMENTS

to the northwest in the Sea of Japan, the tsunami runup was generally large on the west coasts of Okushiri and Hokkaido islands but small on the east coast of Okushiri Island. However, field surveys revealed that the runup height at Hamatsumae (Okushiri) was extraordinarily larger than in the nearby, adjacent areas.

The location of Hamatsumae is on the southeast edge of the island but sheltered from the tsunami source area. Laboratory experiments were carried out by the Public Works Research Institute (Tsukuba) through the use of a hydraulic model of southern Okushiri Island, Cape Aonae. The experiments duplicated the occurrence of the larger waves that were observed at Hamatsumae. Using tsunami wave gauges and VCR analysis of the hydraulic model, it was concluded that two mechanisms accounted for the occurrence of the larger waves. One is the combined effects of the wave refraction and the merging of the solitons due to effects of wave dispersion. The other factor is the nonlinear interaction of two waves intersecting within a narrow angle.

### **Paleotsunami Investigations, Three Papers of Interest**

The following papers are representative of a growing interest in the field of paleotsunami investigations. Field data are useful in determining tsunami runup from pre-historical events with application to inundation models and hazard mitigation strategies.

#### **Discovery of an Ancient Tsunami Deposit in Coastal Sequences of Southwest Japan: Verification of a Large Historic Tsunami;**

*K. Minoura & T. Nakata*

**Abstract:** A tsunamigenic sand layer is present in coastal sequences of the Masuda Plain, southwest Japan. The radiometric age of the layer has been estimated at 930  $\pm$  80 years BP. It is proposed that the deposit is the product of a large historic tsunami believed to have occurred in the Japan Sea on 16 June 1026 AD.

#### **Tsunami Deposits in a Lacustrine Sequence of the Sanriku Coast, northern Japan;**

*K. Minoura, S. Nakaya, & M. Uchida. *Sedimentary Geology* 89(1994) 25-31.*

**Abstract:** Lacustrine deposits of the Pacific coast of north-east Japan, consisting mostly of black organic mud, contain intercalated thin beds of well-sorted medium sand. Examination of the deposits from a coastal site of Sanriku has revealed that sand grains are of marine origin and are fractions of deposits in marshy ponds, transported from the littoral environment by a great flooding of sea water. The mode of sedimentation shown in the thin beds of sand implies that they were

deposited by tsunamis, each with a maximum rise of 1 m or more above sea level.

#### **Investigation of Geological Traces of Paleotsunamis in Kuril-Kamchatka Region;**

*S. Bondevik, V. Gusiakov, A. Kurbatov, I. Melekestsev, K. Minoura, & J. Svendsen.*

**Abstract:** This report describes the logistics and geological results obtained at the first stage of the long-term project of the paleotsunami investigation in the Kuril-Kamchatka region. Principal research objectives of the project are to document the history of the late Holocene paleoseismicity and to determine the tsunami potential of the Kuril-Kamchatka seismic zone using geological methods of tracing historical and pre-historical tsunamis.

During four weeks in July 1993, the international team of representatives of the Russia Academy of Sciences, Tohoku University (Japan) and the University of Bergen (Norway) investigated the sites of tsunami runup in Petropavlovsk-Kamchatsky and Ust-Kamchatsk areas and found some geological evidence for the three most destructive historical Kamchatka tsunamis of 1737, 1923, and 1952, as well as an indication of several pre-historical events.

#### **Mathematical Modeling in Mitigating the Hazardous Effect of Tsunami Waves in the Ocean. A Priori Analysis and Timely On-Line Forecast;**

*Y. I. Shokin and L. B. Chubarov, Institute of Computational Technologies, Novosibirsk, Russia*

**Abstract:** Mathematical modeling application to tsunami problems is determined firstly by a variety of factors characterizing the physical process (i.e. generation of initial perturbation by underwater earthquake, wave propagation over the deep ocean, interaction with floating and fixed objects and runup at the shore) as well as the variety of applied tasks associated with *a priori* studies (coastal zoning, parameter calculation for local and global tsunami warning systems) and with the on-line timely forecasts.

This paper deals with the mathematical models applied to the studies of wave regimes in a wide range of parameters of water areas and initial perturbations, and the calculation of dynamic and kinematic wave characteristics. Special attention is paid to the solution of specific problems including the development of the application software for computer-aided tsunami warning system on the Pacific coast of Russia. Program structures and information fields are described and sample test calculations are presented.

Mathematical modeling in such problems are used for zoning Kuril-Kamchatka coast of Russia with respect to their

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# TSUNAMI WARNING CENTER REPORTS

vulnerability and for parameter calculations for Local Tsunami Warning System in one of the Pacific water areas near Kamchatka. The software system for on-line forecast of tsunami travel times has been used in the operation of Sakhalin Tsunami Warning Center and its basic algorithms have been employed during the preparation of the Atlas of tsunami travel charts for the Pacific Tsunami Warning System developed at the request of UNESCO/IOC. All the algorithms have been tested on model tasks and their accuracy has been estimated. In particular, the error of the determined tsunami travel time does not exceed 3-4 minutes per hour of tsunami wave propagation.

## **Tsunami Society Special Announcement**

The Tsunami Society officers have chosen Dr. Charles L. Mader as the new Technical Editor for the Science of Tsunami Hazards Journal. Dr. T. S. Murty, who has served for eleven years as the technical editor, resigned because he is changing technical fields and assuming an administrative position in Australia. Future articles for the Journal should be sent to:

Dr. Charles L. Mader, Technical Editor  
JTRE-JIMAR Tsunami Research Effort  
1000 Pope Road  
University of Hawaii  
Honolulu, Hawaii 96822 USA

Tsunami Society members are encouraged to submit articles, notes or letters to the new Technical Editor. New voluntary page charges are \$35.00 for Tsunami Society members and \$50 for non-members. An Editorial Board is being established to assist the new editor. If you are willing to become a member of the Editorial Board of the Science of Tsunami Hazards Journal, please contact Dr. Mader.

## **PTWC Report**

PTWC has established an improved, high-speed physical connection to Internet using a T-1 data link to the National Weather Service Forecast Office at Honolulu Airport and thence to the National Meteorological Center in Maryland. This connection should improve Internet reliability and speed for both PTWC and ITIC.



## **ATWC Report**

A week-long working visit to ATWC was made by Charles McCreery (Geophysicist) and Richard Nygard (Electronics Technician) from PTWC. The trip provided opportunities to exchange ideas and for training in the methods and procedures at ATWC. They participated as 24-hour watchstanders and were fully integrated into the watch schedule during their visit. Tom Sokolowski, Geophysicist-in-Charge at ATWC, hosted the working visit.



## Summary of Pacific Basin Earthquakes

*with Surface Wave Magnitudes Greater than or Equal to 6.5  
(data provided by PTWC and NEIC, December 1993 through June 1994)*

Event	Date	Location	Time (UTC)	Lat.	Long.	Dep. Km.	Ms	Mw	Action
93-24	Dec 9	Northern Molucca Sea	0432Z	0.5N	126.0E	33	6.7	6.8	
93-25	Dec 9	Northern Molucca Sea	1139Z	0.4N	125.9E	33	6.4	6.6	
93-26	Dec 29	Vanuatu Islands	0748Z	20.2S	169.8E	33	6.8	6.9	
93-27	Dec 29	Vanuatu Islands	0840Z	20.0S	169.8E	33	6.6	6.5	
94-01	Jan 10	Peru-Bolivia Border	1554Z	13.3S	69.4W	589	-	6.9	TIB*
94-02	Jan 17	Southern California	1231Z	34.2N	118.5W	18	6.8	6.7	TIB
94-03	Jan 19	Irian Jaya Indonesia	0154Z	3.2S	136.0E	33	6.9	6.9	TIB
94-04	Jan 21	Halmahera Indonesia	0224Z	1.0N	127.7E	33	7.2	7.0	
94-05	Feb 11	Vanuatu Islands	2118Z	18.8S	169.2E	204	-	7.0	
94-06	Feb 12	Marquesas Fracture Zone	0416Z	10.8S	128.8W	10	6.5	6.5	TIB
94-07	Feb 12	Vanuatu Islands	1758Z	20.6S	169.4E	33	7.2	7.0	
94-08	Feb 15	Sumatra Indonesia	1708Z	5.0S	104.2E	15	7.0	6.9	TIB
94-09	Mar 9	East of Fiji Islands	2328Z	17.8S	178.5W	564	-	7.6	TIB
94-10	Mar 14	Mexico-Guatemala Border	2051Z	16.0N	92.4W	169	-	6.8	TIB
94-11	Apr 13	Irian Jaya Indonesia	2222Z	3.1S	136.0E	20	6.5	6.5	TIB
94-12	Apr 18	Solomon Islands	1730Z	6.5S	154.9E	43	6.7	6.8	TIB
94-13	Apr 21	Solomon Islands	0352Z	5.7S	154.1E	30	6.6	6.6	
94-14	Apr 29	Argentina	0711Z	28.3S	63.2W	573	-	6.8	
94-15	May 24	Taiwan	0401Z	23.8N	122.4E	33	6.6	6.8	TIB
94-16	Jun 2	Java Indonesia	1818Z	8.3S	113.7E	33	7.2	7.7	TIB 
94-17	Jun 3	Java Indonesia	2107Z	10.5S	112.9E	16	6.4	6.6	
94-18	Jun 5	Taiwan	0110Z	24.5N	122.0E	16	6.5		
94-19	Jun 6	Colombia	2027Z	3.0N	76.0W	33	6.7	-	TIB
94-20	Jun 9	Bolivia	0033Z	13.7S	67.4W	600	-	8.2	TIB
94-21	Jun 18	New Zealand	0325Z	42.9S	171.5E	33	7.1	6.8	

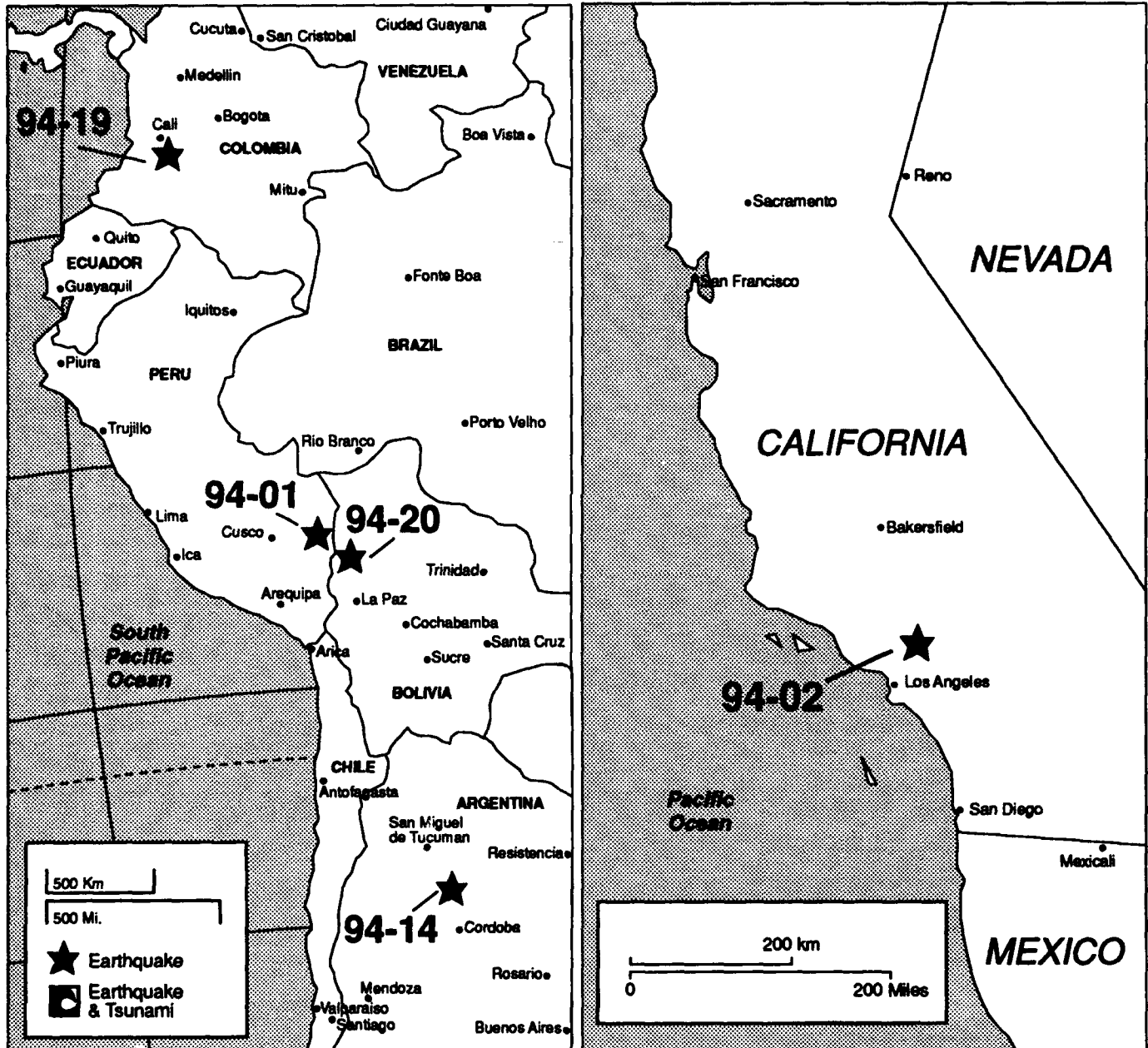
\*TIB - Tsunami Information Bulletin

## (DECEMBER 93 - JUNE 94 BY EVENT NUMBER)



# EARTHQUAKE LOCATIONS

(DECEMBER 93 - JUNE 94 BY EVENT NUMBER)



**MEMBER STATES  
OF THE  
INTERNATIONAL COORDINATION GROUP  
FOR THE  
TSUNAMI WARNING SYSTEM IN THE PACIFIC**

**COMMONWEALTH OF  
INDEPENDENT STATES,  
RUSSIAN FEDERATION**

**DPR OF KOREA  
REP. OF KOREA**

**CHINA**

**JAPAN**

**HONG KONG (UK)**

**THAILAND**

**PHILIPPINES**

**SINGAPORE**

**INDONESIA**

**AUSTRALIA**

**NEW  
CALEDONIA  
(FR)**

**FIJI**

**WESTERN SAMOA**

**TAHITI (FR)**

**COOK ISLANDS**

**NEW  
ZEALAND**

**CANADA**

**UNITED STATES  
OF AMERICA**

**MEXICO**

**GUATEMALA  
NICARAGUA  
COASTA RICA**

**COLOMBIA**

**ECUADOR**

**PERU**

**CHILE**